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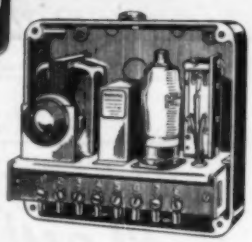

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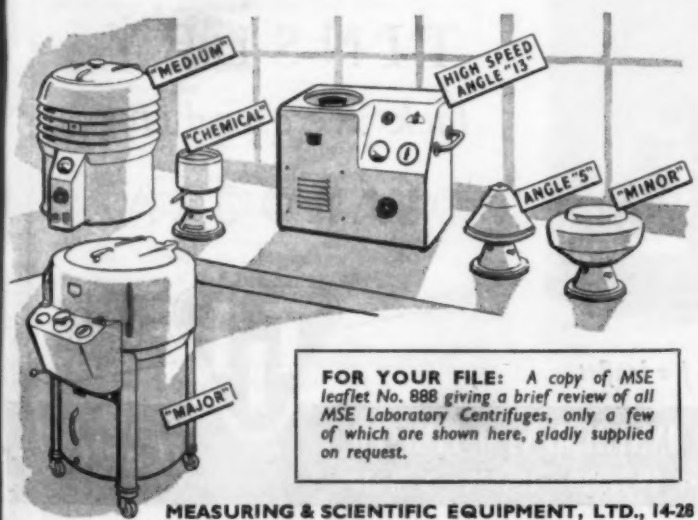

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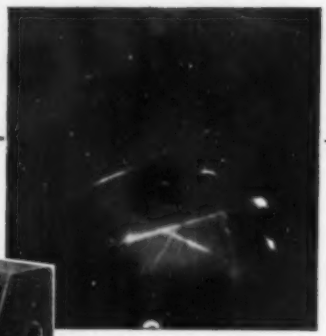

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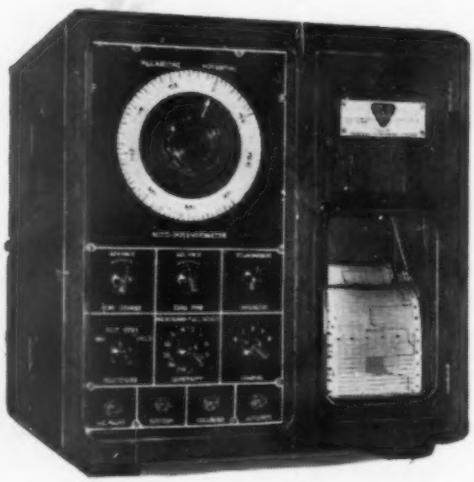

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NATURE

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STATE DEVELOPMENT OF INVENTIONS

THE National Research Development Corporation was set up under the Development of Inventions Act, 1948, to secure the development in the public interest of inventions resulting from public research which, in the Corporation's judgment, are not being sufficiently exploited, and to hold and dispose of rights in inventions arising from such research. At the time, misgivings were felt about its possible effect on the general research organization in Great Britain; but a perusal of the first annual report recently issued* should allay them. All the evidence put forward in this report suggests that the Corporation is likely to strengthen rather than weaken the nation's research structure, and its operations have so far been handled with a wise judgment that has enlisted the co-operation and support of the numerous organizations with which it has had to work. A start has been made which should secure even wider public support as the Corporation becomes better known.

It is not, indeed, possible to judge from this first report how far the real need for such a Corporation has been proved; the information given under dealings in inventions is naturally too meagre for any such purpose. A fuller analysis and more detail will doubtless be supplied in subsequent reports, when with the lapse of time the consideration of prejudicing negotiations no longer applies. On this point, however, there is a suggestion made in the recent report of the Interdepartmental Committee on Social and Economic Research, which, if implemented, might help to supply decisive evidence. A survey of the material available in the Patent Office has impressed the Interdepartmental Committee with the opportunity for useful research which such material presents. In particular, it suggests investigation of such questions as the relations between inventions and the trade cycle, and, on a sample basis, into the number of inventions which are not exploited and the reasons why they are not developed. If examination of this material at the Patent Office indicated, for example, how many projects failed through lack of financial resources and how many were modified or superseded, an independent pointer to the value of the Corporation's work here might be forthcoming in support of the data already accumulated.

Any such investigation would require to be followed up, as the Interdepartmental Committee recognizes, and such follow-up clearly falls within the purview of the Corporation, which might also well be associated with any such inquiry from the start. The suggestion is one that should be carefully considered by the Corporation, and might well fall within the scope of the co-operation with the Board of Trade already established by the Corporation.

The main concern of the Corporation during its first year has been to establish satisfactory arrange-

* National Research Development Corporation. Report and Statement of Accounts for the Period 28th June 1949 to 30th June 1950. Pp. 20. (London: H.M. Stationery Office, 1950.) 6d. net.

ments with the bodies from which it may expect to receive inventions for development and exploitation. Arrangements have been concluded with government departments for the transfer to the Corporation of departmental and public rights in inventions; and some inventions were already being dealt with by the end of the year.

Sensible but less formal arrangements have been established with the Medical Research Council, the universities, the industrial research associations and with a number of other organizations, including the Nuffield Foundation. The research associations are expected to be a particularly rich source of inventions, and rights in such inventions as they may make belong unquestionably to their members. The Corporation, together with the Department of Scientific and Industrial Research and each of the individual associations, has carefully considered the question of assisting each association to utilize to the fullest extent the possibilities of any of its inventions; and it is clear from this examination that the Corporation has the goodwill of the research associations.

In relations with the Medical Research Council, the first consideration has been to preserve the intellectual, academic and ethical freedom of research workers, who have a long tradition of abstention from patenting discoveries in the medical field. No formal agreement has been made for the time being between the Corporation and the Council, although arrangements are in hand for transfer to the Corporation of the patent rights in a number of inventions made by workers responsible to the Council. Furthermore, in this same field the British Medical Association has recognized the Corporation as providing the system of dedicated patents suggested in 1932. Accordingly, it has recorded its opinion that there is no longer any objection to the patenting of inventions for which members of the medical profession are responsible, provided such patents are assigned to the National Research Development Corporation with a view to their administration in the best interests of the public as a whole.

In this field, the Corporation has thus been definitely recognized as a link between the research worker and the industrialist. The same conception is implicit in the arrangement established between the Corporation and the universities. The Corporation considers that it would be contrary to the general spirit of academic freedom to regard the contributions of the University Grants Committee—or of the Department of Scientific and Industrial Research—to university finance as grounds for the automatic transfer of title in inventions from university governing bodies to the Corporation. It proposes to rely instead on voluntary co-operation; but in view of the wish which many university workers immediately expressed to assign their inventions to the Corporation, the Corporation considered it essential that the plans and policies contemplated to secure co-ordination, particularly with respect to the monetary rewards which should accrue to the inventor of a device successfully developed under the Corporation's sponsorship, should have the complete approval of governing bodies.

As a result of lengthy discussions, a document has been drawn up which sets forth the functions of the Corporation in relation to the universities in the United Kingdom. This has been sent, with the approval of governing bodies, to all workers in the universities and university colleges of the United Kingdom, and has already resulted in the submission to the Corporation of a number of interesting inventions. This document is appended to the report, and it explains just how the problem arises of maintaining the free publication, which is in the best tradition of university science, while ensuring that all important inventions arising in universities are protected by patents with the minimum distraction to the research worker, with no delay in publication and without financial, administrative or supervisory burden upon individuals or the institutions.

These last are responsibilities of the Corporation, and in fulfilling them the Corporation hopes to gain acquaintance with the work of the scientific and technical departments of the universities, particularly with work likely to lead to industrially useful inventions. It wishes to build up friendly relations for this purpose, as well as to offer to apply for patents assignable to the Corporation, in consultation with the departments and research worker concerned, for such inventions as appear to the Corporation to warrant protection by patenting. In such activities the Corporation will be specially concerned to see that the administrative work involved in liaison and patenting does not interfere with prompt publication of laboratory results in the usual scientific journals, and that, where the merit of an invention is attributable to an individual, the individual's name is duly associated with the invention. Care will also be taken to avoid destroying satisfactory contacts which already exist between a university and an industry.

So far as the universities are concerned, the National Research Development Corporation is thus proposing to act on an informal basis, much as the patents department of a large industrial firm. Details given in the report are insufficient to judge whether the technical, industrial and patents divisions are adequately staffed for the purpose. Much will obviously depend on the Corporation being able to recruit men of sufficient experience and sound judgment, as well as of appropriate professional qualifications, for these purposes; and only time can show how far it has succeeded in this respect. The Corporation is not, indeed, attempting to provide all the necessary assessment of inventions from its own internal resources. So far as technical merit is concerned, first-class advice can usually be readily obtained from the government laboratories and research stations, or from the universities and industrial research associations. The Corporation is also setting up advisory panels drawn from experts in various groups of industry to advise it on the technical and industrial merits of inventions submitted to it.

Already the Corporation has noted that too many private inventors devote energy and effort to devising inventions which industry either does not want or cannot use without complete dislocation or recon-

struction. In contrast, the three inventions, out of 485 submitted from private sources, which the Corporation selected as meriting public support, were all the designs of qualified engineers with experience in the inventive field to which they had directed their attention.

So far as the development of inventions is concerned, it is too early yet to judge whether sufficient financial resources are at the disposal of the Corporation. For most of the public inventions handled by the Corporation, it is anticipated that the Corporation will be concerned solely with the development of the invention on terms which will make its introduction into industrial practice attractive. Where a development stage has to be contemplated involving use of the Corporation's financial resources, it has been agreed with the Board of Trade, under the Development of Inventions Act, that a limited liability company will be set up, to be owned jointly by the inventor and the Corporation, on terms securing to the Corporation full control over the affairs of the company.

The report also discusses in some detail the principles involved in the exploitation of inventions. The conflict between the relative advantages and disadvantages of the exclusive and non-exclusive licensing policy is regarded as one which can only be resolved in practice by assessing the balance of public interest in each particular case. Further, the Corporation does not wish to discourage the collaboration which has frequently existed between many manufacturers and academic men of science; if the latter now assign their rights in their inventions to the Corporation, the firm concerned would normally be given such initial advantages and exclusiveness in the manufacture of the invention as are consistent with the public interest. The exploitation of inventions relating to food, medicines and surgical or curative devices will, however, be carried out on lines which conform to the intentions of Section 41 of the Patents Act, which requires the Comptroller-General of the Patent Office to grant licences for inventions in this field to all applicants unless, in his opinion, there are good reasons for not doing so.

In this report the Corporation itself recognizes that it is too early to say whether certain fears are justified which were expressed in Parliament during the debates on the passage of the Act; for example, that the Corporation might find it impossible to discharge satisfactorily and simultaneously the three duties laid upon it by the Development of Inventions Act. This first account of its activities, however, shows clearly that, under the chairmanship of Sir Percy Mills, the Corporation has made a good start in a difficult field. By the exercise of good sense and judgment, it has already won a degree of goodwill and co-operation that promises well for the future. Provided its technical staff prove to possess the requisite experience and judgment, there seems every reason for confidence that the Corporation will conduct its affairs so as to secure at least that it acts in the public interest, and collaborates, rather than competes, with existing industries. By winning the public support which enables it to discharge these two duties, the Corporation should be far on the way towards securing whatever further financial resources may possibly be required to enable it to discharge its full responsibilities when the actual development and exploitation of inventions by the Corporation increase.

CHAMBERS'S ENCYCLOPÆDIA: PHYSICAL SCIENCES

Chambers's Encyclopædia

New edition. Vol. 1: A–Autonomy. Pp. xix+848. Vol. 2: Autun–Camorra. Pp. xv+816. Vol. 3: Camouflage–Confession of Faith. Pp. xiv+840. Vol. 4: Confirmation–Educational Psychology. Pp. xv+820. Vol. 5: Edward–Franks. Pp. xiv+856. Vol. 6: Franquelin–Heine. Pp. xv+824. Vol. 7: Heinrich–Izvolsky. Pp. xiv+820. Vol. 8: J–Majesty. Pp. xv+840. Vol. 9: Major–New York. Pp. xv+856. Vol. 10: New Zealand–Pola. Pp. xv+824. Vol. 11: Poland–Rosicrucians. Pp. xv+840. Vol. 12: Roskilde–Spahi. Pp. xv+796. Vol. 13: Spain–Tsushima. Pp. xv+792. Vol. 14: Tuamoto–Zygote. Pp. xiv+856. Vol. 15: Indexes and Maps. Pp. x+815. (London: George Newnes, Ltd., 1950.)

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EVERY research worker knows how essential it is to pause every now and then to sum up the work so far accomplished, and perhaps also to review *ab initio* the particular problem to which he is devoting his attention. It is not sufficient to consider fresh information. It must be correlated with what is already known on the subject, and due weight given to each item. In addition, it may be necessary to consider the general background and history of the subject, and it would be unwise to ignore completely the possible implications to, and applications in, other branches of science and everyday life. As a result of such a survey, new interesting problems may present themselves; or, alternatively, fresh inspiration and encouragement may be needed. For accurate data, reference must be made to the reports of the original investigations; for inspiration and encouragement, to the descriptions of the pioneering works and fundamental discoveries of the acknowledged great masters of science; and for details of the history, general background and practical applications of his subject, to numerous sources covering a very wide range of literature. To assist him in his task, the research worker thus tends more and more in these days to turn to authoritative summaries, digests and up-to-date progress reports on the topics in which he is interested.

Consider now the case of the layman, albeit the intelligent, average educated layman. Whereas the research worker is concerned primarily with only a particular restricted field of inquiry and has usually a specialized training and knowledge, the layman may be called upon from time to time to obtain exact and detailed information, not in one restricted field alone but in many, on subjects covering all phases of human thought and endeavour. Even if all the sources were immediately available, without considerable assistance the task of combing through the literature for the required information would be an impossible one. For one thing, the various technical and other jargons, in which, regrettably, far

too much of the modern work is expressed, would be unintelligible and an almost impassable barrier to progress. Fortunately, for the layman as for the research worker, the necessary assistance has been long provided in the form of that adequate, easily consulted, 'digest of all libraries', the encyclopædia.

During the past 100 or 150 years, several notable encyclopædias in the English language have been published. Of these, "Chambers's" has for a long time been regarded as one of the best. The first edition of "Chambers's" appeared during 1859–68, and was published in 520 weekly parts at the remarkable price of three half-pence each. "Chambers's" has since then run through several editions, which, by careful pruning and revision but without sacrifice of standard, have managed to continue to represent the ever-expanding knowledge of the times, in the most modern fashion, without increasing the number of the original ten volumes. The last ten-volume edition appeared in 1935.

The Second World War, however, ushered in a new period of political, social, economic, and scientific and technical development, and it was inevitable, therefore, that when, in 1944, a new edition of "Chambers's" was contemplated, a mere revision of the 1935 edition was rejected as useless. The task of planning the new encyclopædia was entrusted to Mrs. M. D. Law, who became the managing editor, and who, in the initial stages, had the assistance of such well-known men as Sir Henry Dale, Sir Richard Gregory and Dr. G. M. Trevelyan. The final work is the result of the combined labours of Mrs. M. D. Law, fifty-two advisory editors, nine technical assistant editors, and more than two thousand individual contributors. Not only is the new edition larger than its predecessor, 14½ as compared with 10 million words, fifteen instead of ten volumes, but also, to quote the opening words of the brief editorial preface, "it is in fact an entirely new work, new in conception and plan as well as in execution". Nevertheless, the spirit and tradition of the older "Chambers's" still persists—it is as though a new, handsome, fashionably and well-clad, abundantly healthy and virile person has been created in which to present the revived spirit of the older "Chambers's" to the post-war world.

The traditional alphabetical arrangement has been retained, though others were considered. The various articles, some of considerable length, bear their author's initials, and an alphabetical key to the initials is provided for each volume. In addition, a complete alphabetical index of the names of all the contributors, with references to their major contributions, is included in Volume 15. This seemingly somewhat wasteful duplication could easily have been avoided by attaching the contributors' full names to separate articles. Volume 15 is a distinctly praiseworthy innovation and deserves special mention. The first half of the volume consists of a world atlas, and includes an exceptionally fine series of maps produced by the experienced firm of Bartholomew's, and a detailed index to the place names, etc., shown on the maps. The second half contains, in addition to the index of contributors, a classified list of articles and a general subject index. In the classified list, the various departments of knowledge are grouped into a number of broad classes, and then subdivided into sections; physics, for example, being divided into the following sections: general properties of matter, heat and thermodynamics, sound, light, electricity, magnetism, atomic physics and biographies. The last-named are listed according to countries of origin. It is doubtful whether this classified list will be much used by the ordinary user of the encyclopædia. The general index, on the other hand, is a valuable addition. "It pin-points, wherever it may be in the Encyclopædia, the particular item of information which the reader needs; and it gives a proper selection of references to passages which the enquirer with less-defined needs will find relevant to the topic he looks up."

The planning of each main section and the choice of the appropriate contributors were allotted to an appropriate advisory editor, though which to whom we are not told explicitly. From the list of contributors it would appear that, where possible, the editors have chosen mainly teachers of the highest rank who possess both considerable practical experience of their subjects and experience of imparting their knowledge to others. Thus, the subject-matter in the various articles is well presented and the fundamentals are clearly stressed. In fact, some of the longer articles, especially in the physical sciences, can be described only as model text-books, without that mass of detail which usually clutters up the average undergraduate text-book and which so often obscures the vital points. The shorter articles are equally clear, and both the line diagrams and photographs, in colour and in black-and-white, are numerous, well-chosen and elegantly produced. The biographical thumb-nail sketches of famous statesmen, historians, men of science, etc., are adequate, but give the impression of having been cut down to the bare minimum. Is not Prof. Albert Einstein worthy of more than two-thirds of a column, and must he be still be listed as a German physicist?

With regard to the articles themselves, it is impossible for the present reviewer to do more than give a few brief impressions of those within the mathematical, chemical and physical sections. Some have been read with care and with great interest, and the reviewer has been more than satisfied. Others have been dipped into from curiosity and the reviewer has in many cases been fascinated by the contents. The standard is invariably high. There is some repetition and overlapping, but mainly for clarity and completeness. The mathematics in several cases, perhaps, becomes somewhat difficult and abstruse too rapidly; but then the initial standard of the reader must invariably remain unknown. Physics, which within the past few decades has expanded enormously, has been allotted almost twice the space it occupied in previous editions; but it still takes second place to religion and biology. Recent developments in the branches of applied physics are given due prominence. The importance of the growth of the science of instrumentation is adequately stressed and described by no less an authority than A. J. Philpot. Recent military applications, like radar, infra-red and other electronic devices, are well treated, though strangely enough 'electronics' or 'electronic engineering', which has been described as now the largest industry in the world, is a sad omission as a separate article from the encyclopædia. The fundamentals of electricity, electrical engineering, electrochemistry and the distribution of electricity cover some seventy pages, and the nationalization of electricity in 1947 is briefly discussed, though 'load-shedding' is not mentioned. The main articles on heat and thermodynamics and on light are good; those on spectroscopy by Dr. A. G. Gaydon and interferometry by Prof. S. Tolansky are remarkably clear and, to single out just

one more out of so many similar articles, that on superconductivity by Dr. E. R. Andrew is precise, restrained and well constructed.

It is natural to turn to see what the encyclopædia has to say about the important and topical subject of 'nuclear energy'; but here the physicist who is particular about nomenclature will be disappointed, for he is referred to the less correct 'atomic energy'. First, the stable atom is discussed by Prof. J. R. Partington and, as befits such an able and competent chemist and writer, the account is historically accurate and gives a concise summary of the structure of the atom. Then follows a comprehensive statement of the different types of atomic disintegration apparatus (the absence of the usual photographs of various actual cyclotrons, etc., was noted) and finally an article on atomic energy by Dr. J. L. Michiels, who is also the author of the article on radioactivity. The atomic bomb gets scarcely a mention and the hydrogen bomb none at all. It is stated that "Chambers's" policy is to be impartial on controversial matters; but it is a pity to have suppressed all the exciting details of the original atomic energy project in favour of sober hard facts about nuclear reactions and reactors. There is no special section headed "atomic bomb"; but is there perhaps a chance significance in the fact that the section on "atonement" follows immediately on that of "atomic energy"?

The articles on chemistry, chemical industries, chemical warfare, the individual chemical elements and compounds, and on chemical products such as plastics, fibres and synthetic materials of all kinds, are scholarly and packed with information. Frequently they err on the technical side and assume the reader has more than a nodding acquaintance with symbolic chemistry. However, there is always something to capture the reader's interest, and for the erudite scholar the short bibliographies, appended to the major articles, should prove valuable for further reading and study.

Several minor errors, inconsistencies and omissions have been noted; for example, Dr. Blackman's and Dr. Hoare's definitions of specific heat cannot be reconciled; several physical quantities are stated with incorrect units; 'electrical capacity' is preferred to 'capacitance'; the magnetic amplifier is nowhere mentioned; discussions in many cases obviously date to no later than 1942, whereas others give details of work so recent as late 1948; Weber is deprived of his initials; and the most surprising omission of all is that, with Dr. B. M. Crowther, the editor of *Science Abstracts*, as one of the contributors, there should be no reference at all to scientific information and abstracting services. This, it will be recalled, was the subject of a Royal Society conference in mid-1948. But these are trivialities, and even an encyclopædia of fifteen volumes cannot contain everything or be omniscient.

It is to be hoped that this admittedly brief survey has given some indication of what is, in the opinion of the reviewer, an outstanding British achievement of intellect and craftsmanship. "Chambers's Encyclopædia" is undoubtedly worth one of the highest places of merit among the display of British products at the coming Festival of Britain. It should be consulted by both the scholar looking for detailed knowledge and by the ordinary earnest inquirer. It is assured of success because it is good, for as the editor remarks, "success in this field is necessarily synonymous with good".

S. WEINTROUB

AMERICAN HANDBOOK OF INSECTICIDES

Chemistry and Uses of Insecticides

By Dr. E. R. de Ong. Pp. viii+345. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1948.) 36*s*. net.

THIS book is stated in the preface to be a guide to the established insecticides "and other biocides" for the benefit of the professional worker and college student. It contains chapters on arsenic, copper, sulphur, oils, fumigants, plant derivatives and synthetic compounds. Each chapter concludes with a long list of references, almost all to American literature.

New insecticides, particularly the synthetic organic compounds, appear so frequently and progress so rapidly from the chemist's bench to the salesman's ornate container that the professional worker has difficulty in keeping up to date. He will therefore welcome this guide to the pest control materials available up to 1948. The "Dictionary of Insecticides", a list of chemicals with brief notes on their uses, is a valuable addition. The author has had considerable experience of practical entomology in the western part of the United States and writes of and for that area. Many materials familiar to the British reader are omitted or barely mentioned. Tar distillates, for example, which revolutionized European fruit-growing in the early 1920's, are discussed in eight lines. They are said to have been "largely replaced by dinitro compounds", yet the use of dinitro-*o*-cresol in petroleum oil, the most usual European alternative, is not even mentioned. Some of the uses of petroleum oils and sulphur in the very full chapters on these subjects will strike the British entomologist as most unsafe to the crop, and will illustrate the dangers of adopting without question spray methods devised for crops in widely different climatic conditions.

The chapter headings are on the same lines as those used by Martin (1944) and Shepherd (1941), but the author's approach to the subject is much more from the point of view of the commercial user of insecticides. There is less emphasis on the chemistry of the insecticides and no discussion of the relation of chemical structure to insecticidal activity. On the other hand, more attention is given to subjects of equal importance in practice, such as sources of supply, compatibility of spray materials, phytotoxicity, labelling, packing and inter-State transport regulations. There is also a list of official antidotes.

The chapter on synthetic organic compounds is of the greatest interest at the moment and might perhaps have been extended with advantage. Since the book appears to have been completed in 1947, the organic phosphorus compounds are barely mentioned and some of the recent chlorinated compounds are not included. About one hundred organic compounds are listed and discussed briefly or at length, according to their importance. This section constitutes a survey of the literature, without comment by the author. No attempt is made to assess the relative value for any specific purpose of the compounds listed. The references given would enable the specialist to make this assessment for himself, but the university student would have difficulty in doing so.

The illustrations are mainly of American commercial spraying machines; but they are not mentioned in the text. There are a number of minor

misprints, some unfortunately in the scientific names of insects and chemicals.

The reactions of both insects and crops to chemical treatment are so much influenced by climate, crop-growing practices and varieties of crop grown that it would be almost impossible to write a book which should take account of all these factors. The fact that this one is written for the western part of the United States does not in any way prevent its being of great value to professional workers in other countries.

R. M. Greenslade

PROPERTIES OF GLASS AND PLASTICS

The Strength of Plastics and Glass

A Study in Time-Sensitive Materials. By Dr. R. N. Haward. Pp. viii+245+16 plates. (London: Cleaver-Hume Press, Ltd.; New York: Interscience Publishers, Inc., 1949.) 30*s*. net.

Physical Properties of Glass

By J. E. Stanworth. (Monographs on the Physics and Chemistry of Materials.) Pp. viii+224. (Oxford: Clarendon Press; London: Oxford University Press, 1950.) 21*s*. net.

THESE two monographs reveal the remarkable difference which has developed in the progress of research on the strength or mechanical properties of glass, on one hand, and on viscous, electrical and mechanical properties, on the other.

The study of glass and plastics as solids has yielded a vast amount of experimental results on the strength properties of these materials. In the first book, Dr. R. N. Haward has carefully filtered and separated the available information and produced a source of factual knowledge and a comprehensive summary of the present position in this important field of investigation. It is clear, however, that theoretical work lags far behind the experimental results. Dr. Haward's book is therefore primarily one for reference to experimental techniques and results. From this aspect it should be of value not only to all those interested in the strength properties of plastics or glass, but also to students of the mechanical properties of materials in general. In addition to the reason advanced in the introductory chapter for linking glass and plastics, there might also have been added the combined use of these materials in laminated glass and their many notable similarities particularly at other than ordinary temperatures. A lack of appreciation of transformation phenomena in glasses and, in fact, in all vitreous substances leads, for example, to a somewhat hesitant discussion of the dilatometric transition point of plastics.

The equally excellent and noteworthy summary by J. E. Stanworth of research on those physical properties which have a bearing on present theories of the structure of inorganic glasses just as clearly demonstrates the lack of experimental work, particularly in the fields of viscosity, surface tension and magnetic properties. Theoretical speculations have developed and progressed in a most stimulating manner after the first impetus given by the fundamental ideas of Zachariasen and the experimental deductions of Warren and his co-workers.

A somewhat high proportion of Stanworth's monograph is also concerned with the strength of glass. This duplication is unfortunate, and these chapters could well have been omitted without diminishing the value and interest of the rest of the volume, or perhaps replaced by some information on, say, infra-red spectra of glasses.

A defect common to both authors is the occurrence of instances where a more critical approach to theoretical speculations might have been taken. A point of similarity for which, however, both authors are to be commended lies in the clear and well-written manner in which the subjects, admittedly difficult, have been presented.

It is to be regretted that the rather high price of such important additions to the still somewhat meagre literature on the properties of glass may serve to keep them out of the possession of young technologists, on whom future progress in our knowledge and insight into the structure of glasses, and liquids in general, depends.

H. Cole

SCIENCE AND RELIGION

Science, History and Faith

By Canon Richardson. Pp. vi+210. (London, New York and Toronto: Oxford University Press, 1950.) 6*s*. 6*d*. net; School edition, 5*s*. net.

THIS book is uniform with three others which are being published by the Oxford University Press under the title "A Primer of Christianity" and which deal respectively with the Beginning, the Furtherance and the Truth of the Gospel. Canon Richardson has written especially for those who are conscious of the great importance to-day of the scientific outlook and want to know how Christian faith and Christian theology can claim to be true when measured by scientific standards. The author will undoubtedly hold the audience he has in mind, and his own clarity of style carries with it a deep understanding of the problems involved. The first chapter, "The Knowledge of God", is followed by "Science, Religion and Philosophy", designed for those specially interested in science. The second chapter is divided into parts dealing with the scientific method, the comparative study of science, and the science of theology. The theme is well thought out and is a fair statement of the relation between science and theology. The latter is introduced as "the scientific discipline which studies the phenomena presented by the existence of the Christian religion—its faith, worship, and life—in history and to-day". The layman is helped to the understanding of philosophy by the explanation of terms such as 'naturalism'.

The author's handling of historical evidence is equally convincing, as is also his treatment of miracles. Space is found for discussion of the doctrine of the Trinity, salvation and eschatology. In a concluding section dealing with the preparatory character of this world, Canon Richardson makes a claim for education which is of special significance to-day: "education is the process by which minds are led to choose and cherish the truly valuable ends of life, not for the sake of profit or utility, or in order that the pupils may 'get on' in the world, but simply because they are the ends of life and valuable for their own sake . . . there is a difference between education and propaganda: true education leads the pupil to seek and love value; propaganda deprives him of his freedom and tries to produce in him not a free choice but a mechanical reaction".

H. D. Anthony

THE ETHICS OF EXPERIMENTS ON ANIMALS

By Major C. W. HUME

IN considering this difficult subject, two principles may be taken for granted. First, the relief of suffering in medical and veterinary practice depends on the sciences of physiology, pathology and pharmacology, which in turn depend upon experiments on animals; experimentation is, therefore, in this respect desirable. Secondly, although many experiments involve little or no suffering, others do involve various degrees of it, and the infliction of suffering is *per se* undesirable. There is thus a partial conflict between the two principles, and the problem of reconciling them when it is possible to do so, and of deciding what compromise ought to be made when reconciliation is not possible, is a difficult one which deserves dispassionate study.

Current Practice

Great Britain is far ahead of every other country in the world in its handling of this difficult problem. An admirable account of the British law and practice has been published by the Research Defence Society (1s.), and further information will be found in my chapter in the "UFAW Handbook on the Care and Management of Laboratory Animals". The two main features of the British system are the licensing of experimenters, subject to specified conditions, and the function of the inspectors acting for the Home Secretary. Although the inspectors have disciplinary powers in reserve, the effectiveness of their work depends essentially on the goodwill and co-operation of the licensees, and in any practicable system this must be so.

In many other countries, unfortunately, the situation is far less satisfactory. As regards laboratories in the Latin countries, eminent British physiologists have expressed to me the most emphatic condemnation of procedures they had seen in certain of them. In the United States there is no effective law, but a code of humane conduct has been voluntarily drawn up by biologists, and many conform to it. Others, unfortunately, do not. It would be easy to cite instances; for example, one in which an excessively painful technique, applied by one group of humane research workers to domestic animals under full nembutal anæsthesia, was applied to rats in a state of full consciousness, without any justification whatever, by a different group of workers who, presumably, could not be bothered to maintain anæsthesia.

On the average, biologists are probably more humane than laymen, since they are less likely to regard unpopular species with contempt. But around every average there is a statistical scatter, and it is the workers represented by the lower tail of the distribution curve who make co-ordination desirable. It is possible for intellectual brilliance to co-exist with want of sensibility.

Reconciliation of Conflicting Principles

The problem is best studied in the light of British experience. The two principles enunciated in my first paragraph may be said to be reconciled, wholly or in part, in so far as steps are taken to eliminate or reduce the amount of discomfort or suffering involved.

The comfort of laboratory animals depends mainly on management and handling. In recent years these subjects have received growing attention, which was accentuated by the publication of the "UFAW Handbook"; and the Medical Research Council has recently set up a Laboratory Animals Bureau to advise experimenters on it. No doubt the technical value of hygiene is the main reason given overtly for these precautions, but we may be sure that a humanitarian motive also underlies them. At all events, the need for good animal-management and for large and well-appointed animal houses in which it can be carried out is generally recognized by men of science, although the lay boards of management of some hospitals and institutes could advantageously try harder than they do to make funds available for such purposes.

Still more does the comfort of laboratory animals depend on the laboratory technicians who handle them. The status and prospects of members of this profession need, therefore, to be such as to attract plenty of entrants of the right type. Recently an important step forward has been taken in the formation of the Animal Technicians' Association under the auspices of the Laboratory Animals Bureau. Another encouraging development has been the institution of a course for laboratory technicians (including animal technicians) at the Paddington Technical Institute, with a particularly broad-minded outlook and a specific regard for humanitarian considerations.

Veterinary surgeons could give more help than they are usually invited to give in advising on the handling of laboratory animals. British laboratories might do worse than follow the lead of those in Amsterdam, which have appointed a qualified veterinary surgeon to be their honorary veterinary adviser.

Biological assay not infrequently uses the *LD*50 determination, which involves various degrees of discomfort or suffering. Although it is recognized that non-biological criteria, when available, give greater precision, the supposition that a biological criterion is more relevant to therapeutic potency appears sometimes to count on the other side when the choice has to be made. But the lethal dose and the therapeutic dose belong to parts of the dose-response characteristic which are remote from one another, and one would like to be sure that full account is always taken of the degree of irrelevance introduced by the extrapolation which results from this fact. In any event, the humane motive supplies an additional reason for searching for chemical and physical criteria.

The design of experiments, too, has a humanitarian aspect. Economy in sampling becomes particularly important in any research which may involve discomfort or suffering. Methodologically a pure research may conveniently be thought of as comprising three stages: first, the formulation of an explanatory hypothesis on the basis of previous knowledge; secondly, the deduction from the explanatory hypothesis of a descriptive hypothesis comprising a posited relation between observables; and thirdly, the testing of the descriptive hypothesis

by experiment, so as to verify or refute the explanatory hypothesis which implies it. In this verification process a systematic economy in sampling has been made possible by the methods introduced by R. A. Fisher and his school. But the humanitarian aspect of the first two stages mentioned above deserves an equally systematic study. A particular case with important general implications has been considered in the *British Journal of Radiology* (22, 671; 1949) by Dr. John Read, who suggests that lethal radiation experiments "are not legitimate if planned (*a*) to see what effects will turn up, (*b*) to settle some relatively trivial point, or one that is virtually self-evident, or (*c*) to add fragmentary pieces of unco-ordinated data". Nor yet (*d*) to rediscover something which is already known and recorded in the literature for anybody who will take the trouble to look; nor (*e*) if the probability of obtaining fruitful results is not high. He illustrates these points by reference to determinations of the lethal dose of whole-body radiation, involving mortal illness if not pain, which confound a number of independent factors that a sound scientific method would distinguish. But the whole of Dr. Read's paper deserves careful study by anybody interested in scientific method, and not only by radiologists.

Restrictions on Research

There remains the question: When a proposed research cannot be carried out without the imposition of discomfort or suffering, at what level does it cease to be admissible? What compromise ought to be made between the claims of science and those of laboratory animals when the two cannot be reconciled? Analogy with the commercial treatment of animals is not a satisfactory guide, for barbarous customs still survive. A scientific worker would not wish to take an illiterate trapper as his exemplar, nor conform his ethics to customs which thinking men desire to abolish. In practice the problem has been approached in Britain by absolute restriction in some cases and by relative restriction in others.

Absolute Restrictions

Before 1912 it was assumed that science had an absolute right of way, and that unlimited pain might properly be inflicted if a given piece of information could not be got without it. The Royal Commission which reported in 1912, however, made a contrary recommendation and this, in principle at least, has been adopted by the Home Office, conformably to the fact that the validity of the utilitarian principle is not unlimited.

Two absolute rules are made by the Home Office, and regarded as binding. The first is in effect that all cutting operations must be performed under full anæsthesia. The second is the pain rule which has been attached to every licence since the report of the second Royal Commission, and prescribes, *inter alia*, that if an animal is found to be suffering severe pain which is likely to endure it must forthwith be painlessly killed. This rule is obviously difficult to interpret, but it establishes an invaluable principle, and not the least harmful of the anti-vivisectionists' errors has been their eagerness to make capital out of its difficulties. A partial solution of these will be suggested later; meanwhile their nature must be noted. The licensee is responsible for deciding what is severe pain, and what period of time is denoted by "likely to endure", and this he must at present do without any standards of comparison to guide him. At least two acquaintances of mine have assayed red squill, much as they disliked doing it. The fact that this extremely cruel poison is used extensively in commercial deratization is beside the point; the point is that the work was done under a licence conditioned by the pain rule, and that it consequently illustrates the need for standardizing that rule, to which I shall recur.

Relative Restrictions

When a licence is sought for an experiment which involves discomfort or suffering short of that prohibited by the absolute restrictions, three considerations are relevant. First, there is the assessment of its prospective scientific value, which grows increasingly difficult with increasing specialization. For this and other reasons the scientific qualifications of applicants for licences are important, and it is generally agreed that these are gone into by the inspectors with really great care. Since five inspectors have to deal with 3,445 licensees in 466 places, a heavy responsibility rests on the sponsor who recommends an applicant; but licences are certainly not granted without conscientious discrimination.

The second consideration is one which at present is not officially recognized. It arises out of the fact, already noticed, that no system of control can be effective without the goodwill of the licensees themselves. If, therefore, a licensee is not a strictly humane person, the system will fail in respect of him, but no inquiry is at present made into the moral character of applicants for licences. A relevant fact is that while it is easy to discipline a licensee who has inadvertently made some formal slip, such as furnishing certificate *E* when he ought to have furnished *EE*, it is much more difficult to check a man who has carelessly allowed a rat to recover prematurely from an anæsthetic. Of course, most licensees *happen* to be humane; but it does not seem right that while a candidate for the Civil Service has to show an appropriate moral record, the humaneness of a licensee should be left to chance.

There remains this third and very difficult consideration: What amount of discomfort or suffering is admissible in any given case, regard being had to the importance of the results expected from the experiment in view? We have noticed a similar difficulty already in the case of the pain rule. At present the Home Office refers any new and dubious procedure to the Advisory Committee, and in this way a body of precedents is built up, much as common law and case law are built up from the decisions of judges. But there is this difference, that common law and case law are open to discussion in the legal Press and by the Bar. They are subject to the healthy influence of expert public opinion. But, unlike the judiciary, the Home Office is in the position of a benevolent Star Chamber overwhelmed with business. The only solution hitherto proposed is that experimental procedures should be classified into a small number of grades according to their severity, and licences be correspondingly graded and granted with appropriately graded discrimination. The grades could not be rigorously defined by genus and differentia. The method of indicating them would have to be that adopted in the British law on charities: that is to say, for each grade there would have to be a certain number of type procedures or precedents, other procedures being classified by analogy with them. The precedents would, of course,

be open to continuous review in the light of humane scientific opinion. This proposal has aroused some keen hostility, but with the lapse of time further consideration may perhaps show it to be a logical development of the existing practice; one which might in Great Britain be adopted by administrative action and in foreign countries be embodied in that legislation which is long overdue in almost all of them.

Need for Discussion

The question where the line ought to be drawn between the claims of science and those of laboratory animals is an excessively difficult one about which normal decent people disagree. The only means for arriving at an ideally just solution is frank discussion among humane men of science. But here a real difficulty arises. Anything which may be said in such a discussion is liable to be seized upon, torn from its context, misunderstood and distorted by controversialists who will make an unscrupulous use of it for their own purposes. This fact, and the resentment felt by men of science at the calumnies to which they have been subjected, are obstacles to frank discussion; but they are obstacles which must be over-ridden because obscurantism is an intolerable evil. Moreover, anti-vivisectionist attacks on science are greatly helped by the suspicion that men of science cannot care much about avoiding cruelty since so few of them ever mention the subject except in self-defence.

At all events, here are excessively difficult ethical problems that deserve an increasingly complete solution, and in view of their technical character nobody except humane men of science can solve them.

ANIMAL AND VEGETABLE FOODS

ON January 20, the Nutrition Society held a symposium at the London School of Hygiene and Tropical Medicine on "The Comparative Merits of Animal and Vegetable Foods in Nutrition". Prof. R. C. Garry, in the chair, introduced the subject by referring to the tradition held abroad that the British are great meat-eaters. Economic conditions, he said, are forcing us to reduce our consumption of meat, and a careful examination is needed to consider the nutritional effects of such a change in our food habits.

The need for a source of protein in the diet has been understood for a hundred years. At the turn of the century, German workers demonstrated that individual proteins differed in their nutritive value, and advocated the use of diets high in protein, and with a large proportion coming from animal foods. More recent work has caused some modification of this view.

Dr. G. R. Tristram read an introductory paper on "The Biochemistry of Animal and Vegetable Proteins" in which he said that there is no difference clearly separating the biochemical properties of the pure proteins so far isolated and examined. However, many of the proteins obtained from seeds are partially deficient in one or more of the essential amino-acids. The protein preparations so far obtained from leaves have a more balanced composition. In a normal foodstuff the aggregate of proteins tends to be better balanced in composition than individual members. The non-protein nitrogen fraction of the food may also be of importance. Choline is known to have a methionine-sparing action, and methionine itself has been found to occur free in some plant tissues.

Dr. K. J. Carpenter then spoke on "Relative Nutritional Values of Animal and Vegetable Proteins for Animals". For the rat, the animal feeding stuffs are generally higher in biological value than are the vegetable materials. The experiments used for these determinations are not invalidated by the discovery of the 'animal protein factors', and the differences are explicable in terms of amino-acid composition. For cattle and sheep the proteins of the common feeding-stuffs are approximately equal in biological value, regardless of their amino-acid composition. This may be explained by the synthetic powers of the alimentary micro-flora in ruminants. The practical question for pigs and poultry, continued Dr. Carpenter, is to determine the relative value of different proteins as supplements to a cereal mixture. For this purpose fish meal and milk products are superior to the oil meals, although soya-bean meal is of exceptional value. Recent work at the Rowett Research Institute has indicated that grass proteins are also of lower value than had been predicted from their amino-acid analyses. In some cases the partial deficiencies of the vegetable materials can be compensated by feeding them at a higher level.

The "Conversion Factors of Vegetable and Animal Food for Human Consumption" were discussed by Dr. K. L. Blaxter, who said that Prof. W. C. Rose has recently determined the human requirements for the individual essential amino-acids. It is therefore possible to calculate the production, from an acre of land under various crops, of the vitamins and amino-acids, calculated in terms of man-year requirements. The vegetable crops satisfy greater requirements if used directly for feeding than if used indirectly for meat and milk production. Nevertheless, the provision of requirements by the cereals is unbalanced and lacking in vitamins and protein relative to the provision of calories. In the example of wheat and sugar-beet production, the nutritional value of the crop in terms of 75 per cent extraction flour and refined sugar is significantly supplemented, especially in protein, by the milk production that can be obtained from feeding the by-products—millers' offals and sugar-beet tops—without the use of more land. Animal and vegetable foods are therefore to some extent complementary rather than alternatives.

Dr. D. A. Boyd then discussed the efficiency with which different classes of stock convert vegetable into animal products. The efficiency of energy conversion is approximately 19 per cent for bacon and milk production, and only 7–10 per cent for beef, mutton and egg production. A national balance-sheet of food production and imports shows that, of 21·7 million tons of starch-equivalent fed annually to animals in Great Britain, only 1·9 million tons starch-equivalent is obtained in animal products. This is an overall yield of about 1 : 11, whereas a ratio of 1 : 6 would be expected. This suggests scope for increasing efficiency. The man-hours of labour needed for the production of 1 cwt. of starch-equivalent from animal foods are also considerably in excess of those needed for cereal production. On this basis, wheat is the crop produced with least labour.

To introduce the afternoon session, Dame Harriette Chick spoke of the work done at the Lister Institute on the improvement of vegetable proteins by admix-

ture. In some cases there is important supplementation within a single foodstuff. For example, a mixture of wheat bran and white flour is of greater value for the rat than when each is fed separately. The non-protein nitrogen in potato juice is also of supplementary value to the purified preparations of potato 'tuberin'. This cannot be explained by the amino-acid content of the juice. In these trials with vegetable proteins young rats attained a reasonable growth-rate, but were not able to rear a second generation. In the light of recent American work, this may be explained by the rats having carried a reserve of vitamin B_{12} from their suckling period sufficient for the next few weeks, but not sufficient for a whole life-cycle. For short-term growth, a mixture of soya flour 56 per cent, malt extract of barley 34 per cent and white flour 10 per cent is, on an equal nitrogen basis, equal to whole milk for rats.

Dr. Lucy Mills continued with an account of the results she has obtained in the treatment of 'malignant malnutrition' or 'kwashiorkor' among Zulu children. The condition appears to be identical with the 'fatty liver disease' in the West Indies. After the babies have been weaned from the breast, they receive no cow's milk, or even grubs and locusts as in some primitive societies, and are fed only on porridges made from cereals with occasional green vegetables. They appear to be healthy until the sudden onset of diarrhœa and an œdema, accompanied by low levels of serum albumen. The œdema then usually clears up and the condition enters an atrophic stage. The mortality-rate for children taken to hospital at this stage and put on a normal diet has been in the region of 50 per cent. Post-mortem examination shows a consistent mild normochromic anæmia and an enlarged liver with fatty infiltration. The only treatment so far tested which is really effective is to force-feed the curds from skimmed milk, with nothing else, for several days. There is some evidence that this condition is caused specifically by a deficiency of animal protein. It occurs even when calorie intake is normal. Dr. A. P. Meiklejohn, in the discussion, emphasized the widespread occurrence of this condition and the importance of further research into methods for its treatment and prevention.

A paper on "The Nutritional Adequacy of a Vegetable Substitute for Milk" was then read by Dr. R. F. A. Dean. Of all the constituents of milk the protein fraction is, he said, the most difficult to replace from vegetable sources. Some recent trials have been carried out with children in a home in Germany. Over a sixteen-week period a control group received a diet of butter, potatoes, bread and milk cooked into semolina pudding. Other groups received the same diet with the milk replaced by a soya–barley–wheat mixture. The vegetable mixture, relative to milk, was still slightly deficient in some of the amino-acids; but, when it was fed so that 13 per cent of the calories came from proteins, growth was as good as with the milk ration in which only 11 per cent of the calories came from proteins. Slight changes in the method of cooking the soya flour were, however, liable to produce digestive troubles. When young rats were fed on the vegetable mixture they stopped growing after twelve weeks. This was corrected by the addition of vitamin B_{12} to the diet. The children might have shown a similar deficiency if fed on the all-vegetable diet for longer periods.

In the general discussion which followed, it was agreed that there can be no hard-and-fast rule as to the minimum human requirements for animal (including milk) proteins. Experiments suggest that with a very careful choice of supplementary proteins and with vitamin-rich foods, an adequate all-vegetable diet can be constructed. Nevertheless, in the practical world there appear to be sound reasons for the scientific approval of mankind's enjoyment of animal foods, whether they take the form of roast beef, cheese or merely caterpillars.

K. J. Carpenter

RECENT THEORIES OF TRANSPORT PROCESSES IN LIQUIDS

By Dr. R. EISENSCHITZ

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THE properties of matter in thermal equilibrium can be derived from general principles which are very closely related to the laws of thermodynamics[1] and have a similarly wide range of validity. There is, however, no corresponding general theory determining those properties of matter which are associated with the rate of an irreversible process, such as viscous flow or thermal conduction. This lack of general principles is particularly unsatisfactory with regard to the properties of liquids. There are a number of successful kinetic explanations of some of the properties of the liquid state[2,12], but they are usually not capable of generalization.

In the past four years a new start has been made with the kinetic theory of liquids with the object of substituting methods based on the fundamental principles of dynamics for the arbitrary hypotheses which have often been invoked. In this article the problems, methods and achievements of the recent theoretical work are reviewed with particular reference to the explanation of irreversible processes.

Flow of Momentum and Energy

In the kinetic theory of gases, the flow of momentum or energy which is observed in measuring the viscosity or thermal conductivity of a gas is considered to be due to the momentum or energy which a molecule carries with itself when moving through empty space between collisions. Every molecule is supposed to contribute the product of its momentum and its velocity in the case of viscous flow, and the product of its kinetic energy and its velocity in the case of thermal conduction.

It has been felt for some time[4] that, in liquids, momentum and energy should be considered as transmitted by the action of intermolecular forces rather than by the movement of molecules. The mechanism of transmission has been fully recognized in the case of dense gases (ref. 5, chap. 16), crystals[6], solutions of electrolytes[7] and finally of liquids.

If momentum and energy are transmitted by the intermolecular forces, it is no longer possible to speak of contributions of single molecules but only of pairs of molecules. Every pair contributes to the flow of momentum the product of the intermolecular distance times the intermolecular force, so that the rate at which oriented momentum is added to one molecule is the same as the rate at which it is withdrawn from the other. With regard to the transmission of energy, we can assume that one of the molecules of the pair is at rest, since on the average it is, in fact, at rest. Then the pair contributes to the flow of energy, first, a term which is equal to the product of the potential

energy of interaction and the velocity of the molecule which is considered free to move, and, secondly, a term equal to the distance of the two molecules multiplied by the rate at which the kinetic energy of the relative movement increases in response to the intermolecular forces. It may be added that the flow of energy is a vector and the flow of momentum is a tensor, so that they have three and six components respectively.

These arguments are sufficient for explaining the meaning of expressions obtained by Born and Green (ref. 8, sec. 4) and later by Irving and Kirkwood[9]. The formulæ quoted here are derived from general expressions given by Kirkwood. Let, u, v, w be the components of velocity of a molecule, m its mass, x, y, z, r the relative co-ordinates and the distance of the molecules in a pair, and $\Phi(r)$ the potential of mutual interaction so that $-d\Phi(r)/dr$ is the resultant central attractive or repulsive force. The number of molecules in the unit of volume is N/V and the number of pairs in the unit of volume is $N^2/2V$. The statistical mean (expectation) is denoted by a bar. (It may be recalled that, in general, the mean value of a product differs from the product of the mean factors.)

With this notation, a component of the flow of momentum is obtained as:

$$P_{xy} = m(N/V).\overline{(uv)} - (N^2/2V).\overline{[(d\Phi/dr)(xy/r)]} \quad (1)$$

and a component of the flow of energy as:

$$Q_x = m(N/2V).\overline{[u(u^2+v^2+w^2)]} + (N^2/2V).\overline{[(\Phi u) - [(d\Phi/dr)(x/r)(xu+yv+zw)]}. \quad (2)$$

In both expressions the second term is negligible for gases, and the first term is negligible for liquids.

These formulæ can be evaluated only if the probability distribution is known from which the mean value is to be derived. Although in viscous flow and thermal conduction deviations from equilibrium are small, the equilibrium distribution cannot be used because the resulting mean values would vanish.

Hypothesis of Molecular Chaos

The change of velocity of a gas molecule in a collision is derived from the laws of mechanics. The succession of collisions is, however, considered to be a matter of probability. It is accordingly implied that the velocities before and after a small number of collisions are statistically independent, so that the probability for a final velocity does not depend on the initial velocity. This is implicitly postulated in terms of the hypothesis of molecular chaos (ref. 5, chap. 3), which seems to be necessary for the kinetic explanation of irreversible processes.

A similar assumption is required for liquids, where the molecules are always in a field of force originating from their neighbours and there are no collisions. Kirkwood (ref. 10, sec. 2) formulated an appropriate hypothesis from which he derived important consequences. He assumes that the forces acting on a molecule at different times are statistically independent provided that the time interval is not too small.

This assumption is given a mathematical formulation corresponding to the practice of statisticians. It is postulated that the correlation coefficient between the forces at different times should vanish or, in other words, that the mean value of the product of these forces should be zero.

Let $X_1(t)$ be the x-component of the force which is exercised on the molecule 1 by the other molecules (labelled 2, 3 . . . N) at the time t. It depends, apart from the time, on the initial positions and velocities of all molecules. According to Kirkwood's hypothesis,

$$\xi(t,t') = \overline{[X_1(t).X_1(t')]} = 0 \text{ for } |t-t'| > \tau, \quad (3)$$

where the mean value is taken over the positions and velocities of the molecules 2 . . . N and where the magnitude of τ, the lower limit for the time interval, is discussed later.

The time integral of the correlation coefficient, that is,

$$\int_0^t \xi(t,t')dt',$$

approaches accordingly a 'plateau value' Ξ which is independent of the time. We assume that Ξ is a constant, possibly depending on the temperature.

The increment of the velocity during the time t is equal to

$$\Delta u_1 = (1/m)\int_0^t X_1(t')dt'. \quad (4)$$

The mean value of the square of the increment is accordingly

$$\overline{(\Delta u_1^2)} = (1/m^2)\int d\omega F_0 . [\int_0^t X_1(t').dt']^2$$

$$= (2/m^2)\int_0^t dt' \int_0^{t'} \overline{\xi(t',t'')}dt'',$$

where F_0 is the probability distribution for all initial co-ordinates and velocities in thermal equilibrium, and $d\omega$ is the product of the differentials of the co-ordinates and velocities of the molecules 2, 3 . . . N. It follows that:

$$\overline{(\Delta u_1^2)} = 2\,\Xi\, t/m^2, \quad (5)$$

so that the mean square increment is proportional to the time. The significance of this result is considered in the later section of this article dealing with probability distribution.

The Frictional Force

A molecule in a liquid is subject to frictional forces which arise in spite of the fact that the forces of molecular interaction are conservative.

Let F be the distribution function for the co-ordinates and velocities of the molecules of a liquid at the time t in thermal equilibrium. We express F in terms of the velocities at initial time ($t = 0$) on the assumption that the changes of the co-ordinates during the time interval t may be neglected.

The velocities enter into the equilibrium distribution F by means of the expression

$$\exp\left\{-(m/2kT)\sum_{j=1}^{N}(u_j^2+v_j^2+w_j^2)\right\},$$

in which every factor can be expanded:

$$\exp(-mu_j^2/2kT) = \exp(-mu_{j_0}^2/2kT).[1 - mu_{j_0}\Delta u_j/kT + \ldots],$$

so that

$$F = F_0.[1 - (m/kT)\sum_{j=1}^{N}(u_{j_0}\Delta u_j + v_{j_0}\Delta v_j + w_{j_0}\Delta w_j) + \ldots]. \quad (6)$$

The mean value of Δu_1 vanishes if it is derived from the distribution function F_0 by integrating with respect to $d\omega$. If it is derived from the distribution function F, a term in the expansion (6) gives a non-vanishing contribution although the sum itself may vanish. Using equations (3) and (4), it follows that

$$\overline{\Delta u_1} = -(u_{10}/mkT)\int_0^t dt' \int_0^{t'} \Xi(t',t'')dt'',$$

and this is, by Kirkwood's hypothesis,

$$\overline{\Delta u_1} = -u_{10}\,\Xi\, t/mkT. \qquad (7)$$

Defining a friction constant

$$\beta = m\,\Xi/kT \text{ (measured in sec.}^{-1}),$$

it is seen that $\overline{\Delta u_1}/t = -\beta u_{10}$ is of the same form as if the molecule were a solid particle in a liquid on which a frictional force acts according to Stokes's law. The force does not cause any irreversible heating, since the liquid as a whole is a conservative system. If the liquid is in motion, then u_{10} in eq. (6) is replaced by $u_{10}-u^*$, where u^* is the x-component of the velocity of the liquid.

Similar arguments apply to the movement of a pair of molecules. It does not matter whether the movement is specified in terms of the velocities of the two molecules or in terms of the velocity of the centre of gravity and the relative velocity. Ξ is now to be derived from the total force on a molecule minus the force of interaction of the pair. There are two friction constants, β' for the movement of the centre of gravity and γ for the relative movement.

Whereas the movement of a gas molecule between collisions is readily derived by elementary methods, it is an involved problem to derive Ξ from the movement of a molecule in a liquid. For a first orientation the movement of a molecule may be regarded as a series of almost periodic oscillations about an average position which are interrupted if the molecule occasionally crosses the potential barrier produced by its neighbours. During the oscillations the correlation coefficient of the force fluctuates and vanishes only if the barrier is crossed. The time τ is accordingly much larger than a period of oscillation and is likely to be proportional to $\exp(U/kT)$, where U is the height of the potential barrier. The friction constant β should then be proportional to the same exponential factor.

The friction constant γ will in general differ from β. After deducing from the total force the contribution of a near neighbour, the remaining force is small and has little effect on the actual movement of the molecule. Its correlation coefficient is bound to vanish after a short time—possibly one period of oscillation. γ can also not vary very much with the temperature. The last conclusion agrees with a tentative calculation by Kirkwood (ref. 10, sec. 4). According to a later paper (ref. 9, eq. 20), Kirkwood seems, however, to ignore the difference between β and γ.

The Probability Distribution

According to the theory of the Brownian movement[11], the mean increment and mean square increment of the velocity u of a particle are proportional to the time and equal to $\overline{\Delta u} = -\beta(u-u^*)t$ and $\overline{(\Delta u^2)} = 2\beta kTt/m$, respectively, provided that t is not very small, or very large as compared with $1/\beta$. The mean higher powers of Δu are negligible.

According to equations (4) and (6), the mean increment and the mean square increment of velocity are proportional to the time, and their ratio is equal to $-m(u_{10}-u^*)/2kT$; it is easy to show that the mean values of the higher powers of Δu_1 are negligibly small. It may accordingly be expected, and can be conclusively demonstrated, that on account of Kirkwood's hypothesis, eq. (3), the theory of the Brownian movement applies to single molecules and pairs of molecules in a liquid (ref. 10, sec. 2). This theory provides the means for deriving those probability distributions which are necessary for calculating the flow of momentum and energy by evaluating eq. (1) and (2).

The correct probability distribution for the velocities and co-ordinates of one or two Brownian particles is determined by a partial differential equation (ref. 11, eq. 249). The solution of this equation is, however, a cumbersome problem. The distribution function for the co-ordinates only is approximately determined by a simpler partial differential equation (ref. 11, eq. 312), the equation of Smoluchowski, which is a good approximation if the frictional forces are large enough.

Assuming that the relative co-ordinates of a pair of molecules are statistically independent of the co-ordinates of the centre of gravity, Smoluchowski's equation for the relative co-ordinates reads:

$$\partial g/\partial t = \mathrm{div}[\{(\mathrm{grad}\Phi^*/\gamma m) - \mathbf{c}^*\}g + \mathrm{grad}(gkT/\gamma m)], \quad (9)$$

where $g(x,y,z;t)$ is the probability distribution for the relative co-ordinates and $\mathbf{c}^*$ is the velocity vector of the liquid. The expression in the bracket on the right-hand side is the mean velocity per unit of volume or the density of flow. Φ^* is the mean potential of interaction between the molecules of a pair. In thermal equilibrium,

$$g = g_0 = (1/V)\exp(-\Phi^*/kT), \qquad (10)$$

which is obviously a solution of (9). g_0 determines the probability for finding a molecule at the distance r from another molecule which may occupy an arbitrary position; this probability can be obtained empirically from the X-ray interference pattern of the liquid[3,17]. If the distribution function is known, then the mean potential is defined by (10). In the following discussion the mean potential is assumed to be known as a function of the distance.

In the theory of viscous flow or thermal conduction, $\mathbf{c}^*$ or T is considered as varying with the co-ordinates. In order to find the probability distribution corresponding to steady viscous flow or steady flow of heat, the left-hand side of (9) is assumed to vanish and the resulting equation is solved by successive approximations. A correction term to the equilibrium distribution, which is proportional to the gradient of the (macroscopic) velocity or temperature, is found by neglecting the terms which are proportional to the square of the gradients.

This method was previously applied to the viscosity of dilute electrolytes[7] and was applied by me to liquids[13]. It is found that a flowing liquid is anisotropic even if it is monatomic. Eq. (9) is reduced to an ordinary differential equation with r as independent variable; the problems of viscous flow and thermal conduction lead to almost the same equation. Two boundary conditions are required for integration, of which only one is a direct consequence of the physical conditions. The other has to be chosen in such a way that irregularities of the solution are avoided if possible.

In viscous flow it was postulated that the deviation from the equilibrium distribution vanishes at large distances with a lower power of the distance than -3 in order to prevent the anisotropy from becoming infinite with infinitely increasing volume. In the problem of thermal conduction the boundary condition prevents the local heat flow from becoming infinite if the distance between the molecules is small. The two problems admit a consistent solution only if certain special (and somewhat artificial) assumptions are made with regard to the mean potential. These assumptions are presumably not necessary if the correct theory of the Brownian movement is applied.

Later, Kirkwood, Buff and Green[14] dealt with the problem of viscous flow. These authors started their argument on the basis of the correct theory of the Brownian movement but continued the calculation by means of eq. (9). This equation was integrated under boundary conditions different from those discussed in the preceding paragraph. These authors considered also the case that $\mathbf{c}^0$ corresponds to a uniform expansion and obtained an expression for the volume viscosity.

Viscosity, Thermal Conductivity and Diffusion

The flow of momentum depends according to eq. (1) only on the relative co-ordinates of a pair of molecules, so that the probability distribution in these co-ordinates is sufficient for evaluating (1). The flow of energy is proportional to the velocity; expression (2) can nevertheless be evaluated by means of the distribution function for the co-ordinates[15]; the velocity is proportional to the flow, which can be expressed in terms of co-ordinates by means of the right-hand side of eq. (9). The gradients of velocity or temperature enter as constant factors of the distribution function into the right-hand side of (1) and (2); by omitting these factors, expressions for the coefficients of viscosity and thermal conductivity are obtained.

In this way the transport coefficients were calculated[13]; the result depends upon the friction constant γ. Assuming that this constant is not very sensitive towards changes of the temperature, the results are sufficient for comparing the effect of temperature on the coefficients of viscosity and thermal conductivity. As a consequence of the different boundary conditions which are appropriate to the two problems, the coefficient of viscosity has a factor of the magnitude $\exp(U/kT)$, whereas there is no factor of this kind in the coefficient of thermal conductivity. This is in good agreement with experimental facts and explains the widely different reaction of the two transport coefficients to changes of temperature, which is in striking contrast to the case of a gas. The product of viscosity and thermal conductivity is independent of the friction constant and can be completely derived from equilibrium data. The coefficient of self-diffusion, which is equal to $D = kT/2\mathfrak{z}$, may be expected to be proportional to $\exp(-U/kT)$ if the argument of the section of this article on the frictional force is accepted.

Kirkwood, Buff and Green[14] obtained a numerical value for the viscosity of liquid argon at 89° K. and found the right magnitude; the good agreement with experiment is particularly remarkable because the result is proportional to the friction constant, the derivation of which is so far the weakest link in the chain of deductions.

Born and Green, whose rigorous theory is reviewed in the following section, derived an expression for the value of the coefficient of viscosity (ref. 8, sec. 5) which applies if the radial distribution function does not differ appreciably from the distribution prevailing in thermal equilibrium. They obtain the exponential temperature factor. It would be of great interest to compare their result with the corresponding expression for the thermal conductivity in order to assess the significance of the distortions of the equilibrium distribution.

Foundations for a Deductive Theory

From the theory reviewed in the preceding sections, it should be possible to obtain early results suitable for an experimental test. It is, however, not fully satisfactory because the arguments are somewhat unconnected and depend on haphazard appeals to empirical facts. Kinetic theory aims at establishing an unbroken sequence of deductions from the mechanics of molecules to the numerical values of the transport coefficients. Born and Green were the first to face this problem[8,16,17,18] and to suggest a method of solution. Some of their arguments have also been followed up by Kirkwood[9,10,19].

The theory of irreversible processes should, as a matter of principle, be capable of deduction from Liouville's theorem, which is a direct consequence of the principles of Newtonian mechanics. It is expressed in terms of a partial differential equation:

$$\partial f^{(N)}/\partial t = \sum_{j=1}^{N} \sum_{x,y,z} [(u_j \partial f^{(N)}/\partial x_j) + (X_j \partial f^{(N)}/\partial u_j)], \quad (11)$$

where $f^{(N)}$ denotes the probability distribution for simultaneous values of the co-ordinates and velocities of all molecules. Owing to the large number of independent variables, it has so far not been possible to select a particular solution of eq. (11) which has any significance for transport processes.

This difficulty may be overcome by considering distribution functions for a smaller number of variables, such as apply to the co-ordinates of a single molecule, a pair, triplet, etc. Let these distribution functions be denoted by $f^{(1)}, f^{(2)} \ldots f^{(n)} \ldots$ respectively; these functions convey less information than the distribution function $f^{(N)}$ from which they can be derived by averaging.

The set of distribution functions $f^{(n)}$ satisfies a number of integro-differential equations which are derived from (11) by integrations. In every equation two unknown functions make their appearance, in the first $f^{(1)}$ and $f^{(2)}$, in the second $f^{(2)}$ and $f^{(3)}$, etc. It is plausible to assume that the knowledge of a very small number of these distribution functions is sufficient for obtaining good approximations to all of them (ref. 16, sec. 4 and 6).

Born and Green claim that the probability distributions which are of significance for irreversible processes can be found by solving the set of integro-differential equations according to a scheme of successive approximations (ref. 8, sec. 3). The partial knowledge of the distribution function $f^{(1)}$ is used for determining $f^{(2)}$ uniquely, and this procedure is extended to the higher distribution functions. No additional assumptions or subsidiary calculations are required, and the problems of the kinetic theory are reduced to a matter of computation. It has not yet been demonstrated that this method is capable of predicting experimental results; the only calculations that have so far been published are not conclusive. If this method is successful, an important step towards a general theory of irreversible processes is established.

In conclusion, I wish to acknowledge that part of the arguments of the sections on the hypothesis of molecular chaos and on the frictional force are taken from unpublished work of Mr. G. H. Cole.

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OBITUARIES

Sir Leonard Gregory Parsons, F.R.S.

Sir Leonard Parsons, emeritus professor of child health and dean of the Faculty of Medicine in the University of Birmingham, died suddenly on December 17 at the age of seventy-one years.

Although practising as a general physician, Sir Leonard's main interest was with sick children. It was his view that there was greater scope for research on children's diseases than on those of any other period of life, for disease in childhood could be studied "in its frankest and least complicated forms". He was responsible for the growth and reputation of the Birmingham Children's Hospital—a fact recognized in naming the specially designed infants' block the "Leonard Parsons Block"—and for establishing the University Department of Pædiatrics. He was quick to appreciate the value of biochemistry, and with infinite patience and perseverance built up a research department which has attracted pædiatricians from many schools, and from which young physicians, trained and inspired by him, have gone out to different parts of the world. Appreciation of his academic work has been shown in the many honours that fell to him and in the many invitations to lecture which came to him from learned societies at home, in the United States and in Canada—from the Arris and Gale Lecture in 1912 to the Harben Lectures which he delivered just a few days before his death. His early effort was concerned with nutritional disorders of infants, and the results were embodied in the Goulstonian Lectures (1923). These showed that many of the 'wasting diseases of infancy' are the result of 'qualitative starvation'. Later work clarified clinical problems in vitamin deficiencies, and his studies of fat metabolism in cœliac disease were recorded in the Rachford Memorial Lecture given at the University of Cincinnati in 1932. What may prove to have been his most important work was a large-scale investigation, undertaken between 1930 and 1940, into the anæmias of infancy and childhood. His contributions to the study of hæmolytic anæmia were especially valuable and linked up with the discovery of the *Rh* factor. To the group of diseases related to this, he gave the now generally accepted name of "the hæmolytic disease of the new-born", which, with other ante-natal factors prejudicial to the infant, were impressively reviewed in his Blair Bell Lecture (1945). In giving it the title of "Ante-Natal Pædiatrics" he left no doubt of his conviction of the need for full co-operation between the work of the obstetrician and that of the pædiatrician.

Sir Leonard Parsons was a graduate of the University of Birmingham; but, as was customary in the days when he was a medical student, took his medical degree as an external student of the University of London. He first became a member of the Board of the Faculty of Medicine of the University of Birmingham in 1915 and was made professor of pædiatrics in 1929. Sir Leonard succeeded Dr. Stanley Barnes as dean of the Faculty of Medicine in 1941 and it fell to his lot to steer the Medical School of the University through the difficult period of expansion which took place after 1945. The successful way in which the Faculty of Medicine has progressed over the past five years is in very large part a measure of his skilful and tactful administration.

Frances Braid

Mr. A. H. Hamm

Albert Harry Hamm died at Oxford on January 9 at the age of eighty-nine. During 1897–1931 he had been assistant to E. B. Poulton at the Hope Department of Entomology in the University of Oxford, and was well known as an ardent field naturalist of the old school.

Trained as a printer, Hamm went to Oxford chiefly in that capacity to help Poulton in labelling the vast numbers of accessions; but Hamm was already recognized as an amateur entomologist of high degree. He paid great attention to the courtship of predaceous flies (Empididæ), and his observations on their habits provided evidence of a complete evolutionary series. He collaborated with the late Geoffrey Smith in a study of "Stylops and Stylopisation", and, with Dr. O. W. Richards, communicated to the Entomological Society of London, of which he was a fellow, two papers on the biology of British fossorial wasps. Hamm added much to the knowledge of Sarcophagid flies by breeding many species from dead snails in his garden, so that it was possible for the first time to associate sexes correctly. The small Agromyzid flies, often horticultural pests, were also bred, with their parasites, from their host plants.

An expert photographer, Hamm was keenly interested in the early methods of producing lantern slides by direct colour photography; he also photographed moths in their normal resting places, showing the adaptive significance of attitude and coloration.

His valuable collections, which he gave to the University of Oxford, included the Diptera and Hymenoptera mentioned above; to Dr. O. W. Richards he had given his aculeate Hymenoptera. Special collections of miscellaneous insects obtained from the nests of moles and birds will be kept intact at Oxford; the Diptera will be kept as the Hamm Collection.

The University awarded him the honorary degree of M.A. in 1942; he was an associate of the Linnean Society of London, fellow of the Society for British Entomology, and an honorary member of the South London Entomological and Natural History Society.

G. D. Hale Carpenter

NEWS and VIEWS

Zoological Society of London: Dr. Edward Hindle, F.R.S.

Dr. Edward Hindle retires in April from the post of scientific director of the Zoological Society of London, which he has held since 1944. He is best known scientifically as a parasitologist, and worked for many years with G. H. F. Nuttall in Cambridge. In 1925 he went to China in charge of the Kala Azar Commission of the Royal Society, and, partly, in collaboration with Major Patton, established the method of transmission of the Chinese strain of *Leishmania* by *Phlebotomus*. Afterwards he devoted most of his time to the study of yellow fever and spirochætes, doing pioneer work on yellow fever and preparing the first vaccine in 1928. He was the first to show that the virus of this disease, and also spirochætes, maintain their virulence in the frozen or the dried state. He was also largely responsible for the introduction of the Syrian golden hamster from Aleppo as a laboratory animal.

Dr. Hindle was professor of biology at the Kasr-el-Aini School of Medicine in Cairo during 1919–24, and regius professor of zoology in the University of Glasgow during 1935–43. At Glasgow he was chairman of the Scottish Marine Biological Association and completed the extension of the Millport Laboratory. He was the founder and first president of the Zoological Society of Glasgow, which resulted in the creation of a Zoological Park at Calderpark. He has been a general secretary of the British Association for the Advancement of Science since 1946 and was president of Section D (Zoology) in 1947. He is president of the Zoological Section of the International Union of Biological Sciences, president of the Universities Federation for Animal Welfare, honorary director of the International Wildfowl Research Institute and first president of the Institute of Biology, in the establishment of which he took an active part. He has always been to the fore in promoting the development of zoology in various ways, and not the least valuable of his activities has been the editorship of the *Proceedings of the Zoological Society*.

Dr. L. Harrison Matthews

Dr. L. Harrison Matthews has accepted an invitation from the Council of the Zoological Society of London to succeed Dr. E. Hindle. Dr. Matthews was educated at King's College, Cambridge, where he was Vintner Exhibitioner and gained the Frank Smart Prize of the University for zoology. His interest in the living animal and its environment led naturally to some years on the scientific staff of the "Discovery" Expedition, and to expeditions in South America, tropical Africa, and elsewhere. His numerous scientific contributions cover many aspects of zoology, but more particularly the anatomy and physiology of the reproductive cycle, and range in subject from basking sharks to hyænas and from fiddler crabs to the gorilla. He has contributed monographs to the Discovery Reports on several species of whales, the seals, birds, and some invertebrates of the southern oceans, and on subjects of physical oceanography. During the War he served first with Anti-aircraft Command and later with the Telecommunications Research Establishment, where he was concerned with the introduction of new radar devices into the Services. Since the War he has continued his zoological work at the University of Bristol, where he is research fellow. He has served for some years on the Council of the Zoological Society of London, and as vice-president. He is also a member of council of the Marine Biological Association, a member of the National Committee for Biology, and of the Tsetse Fly and Trypanosomiasis Committee of the Colonial Research Council. He was one of the British delegates to the last International Zoological Congress in Paris, and has served for a time as honorary secretary of the Association of British Zoologists. Dr. Matthews will take up his appointment on May 1 next, and will act as deputy secretary as well as scientific director to the Society.

Baekeland Award of the American Chemical Society: Dr. L. H. Sarett

The American Chemical Society has recently announced that the Leo Hendrik Baekeland Award for 1951 has been given to Dr. Lewis H. Sarett, of Merck and Co., Inc., for his synthesis of cortisone. This synthesis, which was made known by Dr. Sarett in 1946 when he was twenty-eight years old, utilizes cholic and deoxycholic acid, derived from cattle bile, and entails thirty processes. Since the drug is being used for the relief of arthritis, rheumatic fever, etc., it is required in much larger quantities than are available by the present method of production, and work is being done to simplify the synthesis. Dr. Sarett is a graduate of Northwestern University and gained his doctorate at Princeton University. The Baekeland Award, which consists of a gold medal and 1,000 dollars, is sponsored by the Bakelite Division, Union Carbide and Carbon Corporation, and is conferred biennially upon an American chemist under forty years of age in recognition of accomplishments in pure or industrial chemistry. The Award was founded in 1947 to commemorate the achievements of the late Dr. Baekeland, the inventor of 'Bakelite' phenolic plastics.

Large Sunspot Group seen through Fog

Fog prevailing in London and the Home Counties on January 29 and 30 produced the right conditions for seeing a big sunspot group with the unaided eye. This group had come on to the sun's disk on January 23, and by virtue of the sun's rotation, passed across the disk to its western edge on February 3. On January 29, the spot group was therefore most nearly central, and many people became conscious of the black spot on the reddened solar disk. The spots covered an area equivalent to about 1/650 of the sun's hemisphere; but a number of spots as large as this—some being double or even treble this area—have occurred during the past five years, that is, around the peak of the present, very active, 11-year sunspot cycle. About seven out of ten sunspots of a size not less than that of the recent spot are associated with geomagnetic and ionospheric disturbance when the spots are within (roughly) the central half of the solar disk. In the present case, no unusual disturbance was recorded.

Venus and the Earth's Inner Core

Prof. K. E. Bullen has written a paper entitled "Venus and the Earth's Inner Core" (*Mon. Not. Roy. Astro. Soc.*, **110**, 3; 1950) which partly depends on a previous paper (*Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **6**, 1; 1950). In the latter, Bullen constructed an earth model, based on a previous compressibility–pressure hypothesis, in which there is a sharp density increase from 3·36 to 3·57 gm./cm.^{3} at a

depth of 80 km., and thereafter a fairly steady density-gradient down to a depth of 2,700 km. The gradient increases sharply in the next 200 km., the density attaining 5·57 gm./cm.³ at the base of the mantle, while inside the central core it ranges from 9·74 to 12 gm./cm.³ at a depth of 4,980 km., and then rises sharply to a value of 17–18 gm./cm.³ at the centre. In Bullen's more recent paper it is shown that, assuming Venus and the earth are of the same primitive composition, it is probable that Venus also contains an inner core. The earth's inner core, as Bullen has previously pointed out, is chemically distinct from the rest of the earth, and the same is believed to apply to Venus and Mars also, the evidence being based on the mass and radius of Mars, the figure of Mars, and the mass and radius of Venus, assuming that the model mentioned at the beginning of the paper fits the earth. The ellipticity e of Venus can be derived from the formula $e = (1{\cdot}68 \pm 0{\cdot}07)10^{-6}y^{-2}$, if the period of rotation of Venus is 20 y days. This formula, however, can be significant only if y is much less than unity, and present indications of the rotation period of Venus do not suggest this as being very probable. On the other hand, if y is of the order of unity, the value of e would not be resolvable by direct observation, and in any case would be dwarfed by surface inequalities sustained by the strength of Venus. For these reasons, little help can be derived from observations of the figure of Venus at present.

Parliamentary and Scientific Committee: Annual Report

The activities of the Parliamentary and Scientific Committee (31 Palace Street, London, S.W.1) have for the most part been noticed in *Nature* as they occurred; but the annual report recently issued also includes the text of a letter from the Minister of Education commenting on the Committee's report on technical education and indicating his readiness to receive a deputation. The Minister observes that he fully recognizes the importance of craft training and the need to combine organized practical training in the works with technical education in the colleges. While the Ministry is encouraging voluntary day release and the provision of more practical courses leading to qualifications of the City and Guilds of London Institute, and the Minister shares the Committee's view as to the expansion of secondary technical schools, he doubts whether such schools are appropriate for technical education. Detailed surveys of industrial needs have already been made by most of the local authorities in preparing their Schemes of Further Education and plans for county colleges. The Ministry is doing its best to improve accommodation and equipment, and some £50 millions of new buildings were begun in the last year, the highest priority being now given to workshop and laboratory accommodation. Afterwards, on November 22, 1950, a deputation from the Committee discussed in detail with the Minister the implementation of these and other recommendations on which the Minister had commented. The report also includes the text of a letter from the Committee's chairman, Mr. Philips Price, to *The Times* (November 24, 1950) urging further effort to secure greater efficiency in the field of coal utilization, and an adequate investment for the installation both in factories and houses of the most efficient coal-burning and coal-using equipment that science and technology can devise, as well as the intensification of research in this field.

Division of Chemical Physics of the American Physical Society

The Council of the American Physical Society, as requested in a recent issue of *Physics Today*, has revived the idea of establishing a Division of Chemical Physics, and a committee consisting of Dr. F. G. Brickwedde, Prof. J. G. Kirkwood, Dr. J. E. Mayer, Prof. H. H. Nielsen and Prof. O. K. Rice, with Prof. R. S. Mulliken as chairman, has drawn up a draft set of by-laws. The principal objective of the new Division is stated to be "the advancement of understanding in subjects of chemical interest whose development depends strongly on modern physical theories or techniques". Membership of the new Division is open to all members and fellows of the American Physical Society on application. An entrance fee is payable, but no annual subscription. It is hoped to inaugurate the Division at the meeting of the Society in Pittsburgh during March 8–10, which will comprise a symposium on molecular structure and valence theory and on topics involving statistical mechanics. This will be followed in June by a symposium on molecular structure and spectroscopy.

Society of Plant Morphologists

During the recent annual session of the Indian Science Congress, held at the Indian Institute of Science, Bangalore, a large group of Indian botanists interested in plant morphology met on January 4 and decided to form a Society of Plant Morphologists. It was resolved that the Society should start a *Journal* devoted to all aspects of plant morphology from Algæ to Angiosperms and run it on an international basis. Pending formal election of office bearers some time next year, it has been arranged that Prof. P. Maheshwari, head of the Department of Botany, University of Delhi, Delhi 8, should act as convener of the Society and editor of the *Journal*. Inquiries relating to the Society and all subscriptions should be sent to Prof. Maheshwari. The annual membership fee is £2 for botanists residing outside India. For non-members the subscription to the *Journal* is £2 5*s*.

National Capital Wealth of Great Britain

In the annual report for 1949–50 of the National Institute of Economic and Social Research (pp. 32; from 2 Dean Trench Street, London, S.W.1), the approaching completion of a stage in the work of the Institute is announced, and its future plans are briefly explained. Hitherto, a large part of its resources have been devoted to the study of the national income of the United Kingdom and the establishment of the basic statistics in this field. The Institute now proposes to undertake a number of studies in the field of capital, of which the first will be a critical appraisal of historical estimates of the national capital, the concepts used, and the statistical methods and sources employed. Very little work, it is pointed out, has been done during the past fifteen years on the national capital, despite the greatly increased interest in the study of the national income, and despite the fact that in the nineteenth and the early years of the twentieth centuries frequent attempts were made to estimate the national capital. If feasible, these earlier estimates will be recalculated on a more uniform basis, and an attempt will also be made to link up estimates of the magnitude and composition of the national wealth with annual estimates of capital (or asset) formation. It is believed that it

may be possible, in certain areas at any rate, to build up more detailed estimates of capital in different branches of industry according to type of real asset.

The Peacock Butterfly in Scotland

A NOTE by D. W. Hall in a recent issue of *The Scottish Naturalist* describes the present distribution of the peacock butterfly in Scotland. Some twenty years ago the peacock was unknown in Scotland; but, by 1945, it was common in the Border country and was working steadily northwards, one isolated record from Caithness having been recorded. The first recorded observation was made at Crinan, Argyllshire, in 1935, where, in 1948, it was reported to be common. During the spring of 1948 it was reported as being the commonest species of butterfly near Oban, Argyllshire. In Inverness-shire it became common in Canna and Eigg and was a well-established resident in the Hebrides by 1948; it can now be said to be quite common in the Western Highlands and Islands. Records have also been made in central Scotland, while in eastern Scotland the peacock butterfly has become very common in Perthshire and Angus. Migrating swarms as known in France and England have not been observed in Scotland.

"The Rationalist Annual"

ORIGINALLY published as the "Agnostic Annual", the "Rationalist Annual" is now in its sixty-eighth year of publication. The 1951 issue maintains the high standard of its predecessors and includes articles by Prof. J. B. S. Haldane on the rate of evolution, J. C. Flugel on the present position of psychoanalysis, Robin Skynner on the Communist attitude to semantics, Avro Manhattan on arts and men, Lord Chorley on the growth of law, Archibald Robertson on grounds for disbelief in God, Maurice Burton on the impact of fear on animal behaviour, A. Gowans Whyte on the recent memorandum prepared by the Religious Bodies Consultative Committee, F. H. George on psychology and semantics, Royston Pike on Edward Gibbon and, finally, D. Stark Murray on the need for a rational attitude to health. The journal is edited by Frederick Watts and may be obtained from Watts and Co., price 2*s*. 6*d*.

List of Periodicals in the Science Museum Library, London

A SIXTH edition of the "Hand List of Short Titles of Current Periodicals in the Science Library" (pp. 282; London: H.M. Stationery Office, 1950; 7*s*. 6*d*. net), which has recently been published, will be welcomed as giving a picture of the periodicals now being received at the Science Museum Library, London, but does not completely replace the older editions of the List. Periodicals are entered only under their present titles, and there are no cross-references, although the holdings shown are those of the periodical under all its titles. The List shows only the major gaps, however, and it is not a catalogue of all the periodical holdings of the Library. A format based on photography from a visible index has been adopted instead of print, so as to facilitate re-issue. Shelf marks are given at the end of the entries, and users are asked always to quote them when requisitioning. The order of entries is that of the "World List of Scientific Periodicals", with the exception that journals, bulletins, reports, etc., of societies, institutions, etc., precede periodicals having distinctive titles commencing "Journal", "Bulletin", etc., and are not in one alphabetical order, as in the "World List".

Announcements

DR. E. U. CONDON, director of the United States National Bureau of Standards, has been elected president of the Philosophical Society of Washington. Founded in 1871, the Philosophical Society is the oldest Washington society devoted to the promotion of science, and its first president was Joseph Henry.

COLONEL E. H. THOMPSON has been appointed to the University chair of surveying and photogrammetry tenable at University College, London. The title of reader in geography in the University of London has been conferred on Mr. A. E. Smailes in respect of the post held by him at University College.

THE Council of the City and Guilds of London Institute has conferred the fellowship of the Institute on the following past students of the City and Guilds College: Dr. G. Roche Lynch, senior official analyst to the Home Office and director of the Department of Chemical Pathology, St. Mary's Hospital, London; Sir Harold Saunders, recently Comptroller-General of Patents, Designs and Trade Marks and Comptroller of the Industrial Property Department, Board of Trade; Mr. S. Scott-Hall, principal director of technical development (air), Ministry of Supply; Dr. R. L. Smith-Rose, director of radio research, Department of Scientific and Industrial Research; and Mr. M. T. Tudsbery, civil engineer to the British Broadcasting Corporation.

MR. DONALD B. MOORE, district manager of North Eastern Trading Estates, Ltd., has been appointed general secretary of the Textile Institute, in succession to Mr. Harry Ibbetson.

THE Medical Research Council, by arrangement with the Centre National de la Recherche Scientifique, is offering two scholarships, worth 40,000–60,000 francs a month plus marriage allowance, which are open to British graduates for research in medical science, excluding clinical medicine, to be conducted at research institutions in France during the academic year 1951–52. Candidates should have had some previous research experience and must possess a working knowledge of French. Application forms, obtainable from the secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1, must be completed by March 31.

A CONFERENCE on "The Use of the Film in Training for Industry" has been arranged by the Scientific Film Association and will be held in the Hotel Majestic, St. Annes-on-Sea, Lancs, during March 30–April 1. The main part of the programme, on March 31, will be divided into three broad sessions dealing respectively with films for training in the textile, engineering and building industries. Both professionally-made and amateur-made films will be shown. The fee for the conference is one guinea. Further details can be obtained from the secretary of the Association at 4 Great Russell Street, London, W.C.1.

WE are asked to point out that the Commission for Very Low Temperatures (*Nature*, January 27, p. 138) is a commission of the International Union of Pure and Applied Physics, and not of Unesco, as stated. Correspondence referring to the Commission's conference on low-temperature physics during August 22–31 should be sent to the Organizing Committee, Low Temperature Conference, Clarendon Laboratory, Parks Road, Oxford.

SPONTANEOUS GELATION OF ALKALINE CASEIN DISPERSIONS

By K. F. PLOMLEY, H. G. HIGGINS and J. F. HAYES

Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Melbourne

SOME protein systems containing only monovalent alkalis, for example, casein – sodium hydroxide – water, are capable of spontaneous isothermal gelation without removal of solvent. Such a phenomenon clearly requires either direct interaction between the protein molecules or the intervention of alkaline degradation products, and is thus quite distinct from the gel formation observed, for example, in the presence of divalent cations[1] and aldehydes, which can provide bridges between free carboxyl and between amino[2] (or between amino and amide[3]) groups respectively.

In the system casein – sodium hydroxide – water, the gelation process has been found to be specific to a limited *p*H range. Experiments were carried out at 25° C. on two series, each of constant protein concentration, the final ratios of casein to water being 2 : 5 (series 1) and 2 : 7 (series 2) based on the air-dry weight of the protein. Solutions of different *p*H were examined in a Stormer viscometer in the manner described previously[4], and the dependence of the viscosity, η, on T, the time in minutes from the addition of the alkali to the protein, was determined, neglecting, for purposes of comparison, deviation from Newtonian flow and using the data for an actuating weight of 200 gm. Typical η—T curves are shown in Fig. 1. The 'rate of gelation', $d\eta/dT$, was obtained for an arbitrary value of T from the slope of the tangent to the η—T curve.

The dependence of η on *p*H is shown in Fig. 2 for $T = 60$ (series 1) and $T = 150$ (series 2); these periods were necessary to effect colloidal dispersion. As the η—T curves are essentially linear only below *p*H 12·5, their extrapolation to zero time has not been attempted; and small time effects are therefore included in the values of η plotted in the η—*p*H curve, which may account for the rise in the viscosity towards very high *p*H. However, the shape of the remainder of the curves is essentially valid, and resembles the behaviour of the sodium caseinate solutions of Nitschmann and Guggisberg[5]. The development of the net charge on the micelles as the *p*H of the protein solution is raised leads at first to a viscosity increase in accordance with Smoluchowski's effect[6]. At still higher *p*H the decline in viscosity may possibly result from reduction in the zeta-potential under the influence of cations adsorbed at the inner side of the diffuse double layer.

The variation of $d\eta/dT$ with *p*H, as shown in Fig. 2 for $T = 180$, is an indication of the extent of molecular interaction, although intramolecular effects are not necessarily excluded. In the region above *p*H 13·5 the viscosity at first increases rapidly with time, but later passes through a maximum (Fig. 1), and the subsequent decline is accompanied by a decrease in opacity, and the production of proteoses. The net decline in $d\eta/dT$ above *p*H 13·5 could be due in part to alkali inhibition of reactive groups; but the effect is so large that it must almost certainly be ascribed mainly to molecular breakdown, involving hydrolysis of peptide bonds. The maximum in the curve, reflecting the opposing effects of gelation and hydrolysis, further suggests that the new intermolecular bonds are less alkali-labile than some, at least, of the peptide linkages, since they are capable of forming under the conditions of peptide hydrolysis. The numerical superiority of the relatively labile peptide bonds eventually overwhelms the tendency towards gelation, which must operate initially at the surface of the protein molecule or micelle.

Evidence favouring the formation of stable covalent bonds is also to be found in the irreversibility of the gelation process. Gel material prepared at *p*H 13·2 was broken up in a Waring blendor, brought back to the isoelectric point of the original protein, dialysed to remove salt, and dried. Gelation with sodium hydroxide solution could not now be achieved. Further, the gel material was soluble in $M/15$ phosphate buffer to the extent of only 0·030 gm./100 ml. when 0·1 gm. was added to 100 ml. buffer, as against 0·87 gm./100 ml. for the untreated casein; even this low degree of solubility is probably attributable mainly to an interstitial sol fraction. Again, over a wide *p*H range, gels forming at *p*H 13·2 do not break down easily in excess water, although swelling of the order of 10–10³ times the original volume indicates that the intermolecular network must be rather loose. For this reason also the gels are relatively weak and are easily deformed elastically under shear stress.

The possibility of the gelation mechanism involving a simple salt linkage seems to be inconsistent with the specific conditions of *p*H required. An examination of the characteristic acidity constants of the ionic groups of proteins[7] shows, for example, that in the trough in the $\frac{d\eta}{dT}$—*p*H curve of Fig. 2 (from

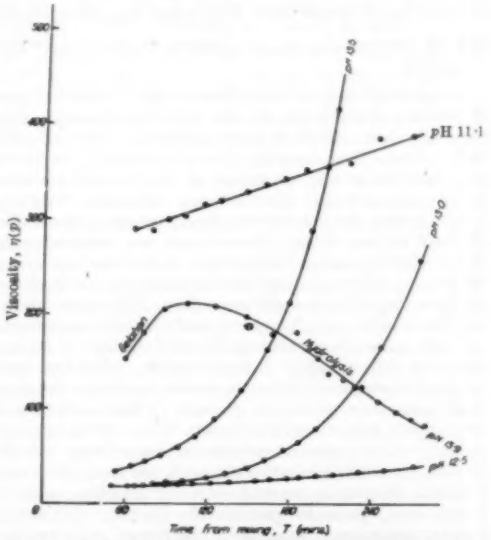

Fig. 1. Typical viscosity-time curves for different regions of the high *p*H range (series 1)

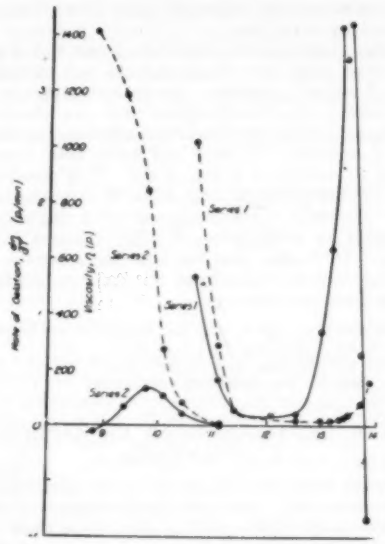

Fig. 2. Dependence of viscosity, η, and rate of gelation, $d\eta/dt$, on pH: ----, η; ———, $d\eta/dT$ for $T = 180$

c. pH 11·5 to 12·5) oppositely charged side-chains would be more abundant than at higher *p*H, where $d\eta/dT$ is nevertheless much larger. Further, at high *p*H the repulsive effect of strong net negative charges on adjacent micelles might be expected to hinder electrostatic attraction between oppositely charged specific groups. Ion – dipolar ion interaction in the *p*H range 11·5–12·5 is not precluded, however, as shown by the fact that gels can form here in the presence of divalent cations (calcium).

In the region below *p*H 11·5, the increase in viscosity with time follows an approximately linear course (Fig. 1) rather than $d\eta/dT$ increasing with time as it does above *p*H 12·5. The system finally has high viscosity but does not possess the rigidity of the high *p*H gels and is dispersible in water. These results indicate different mechanisms for the two regions.

In order to determine the possible effect of intramolecular changes on the gelation process, a series of investigations has been made into the properties of casein treated with sodium hydroxide solution at different *p*H values and protein concentrations. After treatment for 60 min. at 25° C., the systems were rendered isoelectric with hydrochloric acid and salt was removed by dialysis. Viscosity studies were made at 21·8° C. on dilute solutions of the various preparations in *M*/15 phosphate buffer using Ostwald tubes. Axial ratios were calculated from the tables of Mehl, Oncley and Simha[8], using values of the increment of viscosity derived from the observed mean ratio, for three concentrations, of the specific viscosity to the concentration, and from the value of the partial specific volume for whole casein (0·73) given by McMeekin, Groves and Hipp[9]. The viscosity increments are adjusted for an assumed degree of hydration of 0·4 gm. solvent/1 gm. protein[7], and if it is assumed that the molecules have the general shape of prolate ellipsoids, the mean axial ratios are as shown in the accompanying table for treatment groups relatively homogeneous in respect to viscosity increment. There is no evidence of an unravelling of the polypeptide chains: on the contrary, the molecular symmetry increases on treatment at high *p*H.

AXIAL RATIOS OF ALKALI-TREATED CASEIN

Treatment		Mean viscosity increment (uncorrected for hydration)	Mean axial ratio; for hydration = 0·4
Casein : water ratio	*p*H range		
2 : 5	9·7–13·4 13·4–13·9	17 8·3	8·5 4·6
1 : 225	10·4–13·2 13·2–13·5	19 11	9·1 5·8
Untreated		20	9·6

Evidence of denaturation has been observed among the other conventional criteria, but none suggesting unfolding of the chains. After treatment with alkali, hydrogen sulphide is evolved upon return to the isoelectric point; this may be connected with a splitting of the molecule. X-ray powder photographs of untreated casein and of casein at various stages of alkali treatment showed only the backbone and side-chain spacings of Astbury and Lomax[10], and no development of the outer ring corresponding to a Bragg spacing of 3·6 A. which is characteristic of some denatured proteins, such as egg albumen.

The search for the specific groups concerned in the gelation process, and their mode of linkage, is proceeding. The work described here was carried out as part of the programme of the Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Australia. We are indebted to Dr. A. B. Wardrop of this laboratory for the X-ray photographs. [Aug. 1.

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MYXOBACTERIA IN SOILS

Use of Rabbit Dung Pellets to Detect Myxobacteria in Soils

THE distribution of Myxobacteria in different types of soils has hitherto attracted very little interest. The first investigation systematically carried out was made by the Krzemieniewskis[1], who in 1926 searched for them in Polish soils. The method of isolation of Myxobacteria used by them was very simple; about 150 gm. of the soil to be examined was distributed in large Petri dishes and a large number of autoclaved rabbit dung pellets were placed on the surface of the soil. Species of Myxobacteria began to form fruiting-bodies within a few days. In this way it was possible for the Krzemieniewskis to state that "Die Myxobakterien sind ständige Bewohner des Bodens" (*l.c.*, p. 139). From the frequency with which species of Myxobacteria occurred on the rabbit dung, they drew further conclusions on the influence

of incubation temperature and of soil *p*H. It is, however, very dangerous to draw definite conclusions from results obtained in this way, since it is not possible to standardize the quality of the rabbit dung, nor are the pellets in every case a suitable substratum for the development of the majority of Myxobacteria.

Attempts to isolate Myxobacteria were made in 1949 in Uppsala, and during the summer of 1950 at Rothamsted Experimental Station. In these experiments use was made of dung pellets—fresh and stale—from tame rabbits. Before use, the pellets were washed in water and autoclaved at about 15 lb./sq. in. for 10 min. About twenty of these were placed on the surface of the soil sample in a Petri dish which was incubated at 25° C. In the investigations at Rothamsted, the presence of Myxobacteria in soil was also tested by Singh's method[3]. *Aerobacter* (strain 1912 [5]), grown on nutrient agar slopes for six days, was spread on the surface of non-nutrient agar (1·5 per cent agar, 0·5 per cent sodium chloride) of *p*H 6·6–7·2 to form a 'bacterial circle', about 2·5 cm. in diameter. Three such circles—here called '*Aerobacter* circles'—were made in each Petri dish and about 0·5 gm. soil was placed in the centre of each circle. Each soil was tested on six circles. The plates were incubated at 25° C. for three weeks.

Seventeen soils were examined and in all of them Myxobacteria were found. The number of Myxobacteria found on rabbit dung was quite different from that found on the '*Aerobacter* circle'. A comparison of the results is summarized in the accompanying table.

Growth of Myxobacteria from Seventeen Fresh Soil Samples on Rabbit Dung and on '*Aerobacter* Circles'

Substratum for isolation	Number of soils with			
	Myxococcus virescens	*Myxococcus fulvus*	*Chondrococcus coralloides*	*Archangium* sp.
Rabbit dung	2	1	10	6
'*Aerobacter* circle'	14	3	11	0

Myxococcus virescens was obtained from fourteen soils on '*Aerobacter* circles' but only from two soils on rabbit dung. Thus in twelve cases this species, although present in the soil, did not develop on rabbit dung. The same tendency is shown by the rarer species *Myxococcus fulvus*. This shows that failure to find Myxobacteria on rabbit dung pellets does not necessarily indicate that they were absent from the soil examined. It indicates rather that the rabbit dung was an unfavourable medium for this species. On the other hand, *Chondrococcus coralloides* developed on the pellets almost as well as on the '*Aerobacter* circles'.

In the earlier investigations in Uppsala, it was very easy to obtain *Myxococcus virescens* and *Myxococcus fulvus* on rabbit dung[4]. In these experiments fruiting bodies of the genus *Archangium* were also found frequently. These were always very large, visible to the naked eye and of a reddish-blue colour. In the experiments at Rothamsted the fruiting bodies of *Archangium* were small and mostly with few convolutions. Their colour was generally white or sometimes pale red. Thus it seems that the rabbit dung pellets used at Rothamsted provided a substratum quite different from those used at Uppsala.

These observations show that rabbit dung pellets do not constitute a constant substratum, and hence that comparable results concerning the distribution of Myxobacteria in different types of soil cannot be obtained by their use.

Singh's method of isolation from soil has the advantage that the Myxobacteria can develop on a standardized medium. It is not clear in these experiments why *Archangium* did not develop on '*Aerobacter* circles', as Singh[3] reports having found it by this method. It may not have been abundant enough to occur in 0·5 gm. of soil. It is possible that Singh's method would yield more Myxobacteria if the 'bacterial circle' were composed of a different food bacterium or a mixture of two or more bacterial strains. It is also possible that the content of 0·5 per cent sodium chloride in the agar prevents some species from developing.

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Effect of Soil Treatment on the Occurrence of Myxobacteria

In view of the antibiotic action of some species of soil Myxobacteria, their relative abundance in different soils becomes of interest. A search for these organisms in various soils was made, using the method of '*Aerobacter* circles' described by Singh[1].

In all, seventeen different soils were examined at Rothamsted during August 1950. These included samples from plots receiving, respectively, no manure, farmyard manure and complete minerals plus ammonium sulphate on Broadbalk and Barnfield at Rothamsted and on Stackyard Field, Woburn, Beds. The Broadbalk plots have received the same manures since 1843, the Barnfield and Woburn plots since 1876. The remaining eight soils were collected from other fields in Rothamsted and Woburn.

Myxobacteria were obtained from every soil. The species were: *Myxococcus virescens*, *Myxococcus fulvus* and *Chondrococcus coralloides*. Fruiting-bodies which appeared to be of *Polyangium fuscum* were also found, but as they have not yet been obtained in pure culture definite classification is not possible.

A satisfactory method of counting Myxobacteria in soil is still lacking. In this investigation an attempt was made to assess the frequency of one species in a soil by counting the number of '*Aerobacter* circles' in which it developed. Each soil was tested in six circles. With this method of assessment, the untreated soils from Broadbalk, Barnfield and Stackyard Field formed one group, those from the complete mineral-treated plots a second group and those from the farmyard-manured plots a third group. Each group contained three soils and was thus tested in eighteen '*Aerobacter* circles'. Although this number is not sufficient to permit definite conclusions, some observations can be made.

(1) *Myxococcus virescens* was found most often and *Myxococcus fulvus* least frequently.

(2) No differences were observed in the abundance of Myxobacteria as between untreated and complete mineral-treated soils.

(3) All three species were found most frequently in the farmyard-manure treated plots. This may be due to the greater number of suitable Eubacteria or to the farmyard manure itself favouring the growth of these Myxobacteria.

The relation of occurrence to soil reaction was examined in twelve of the seventeen soils. These fell into three groups: acid soils (*p*H 4·1–5·5); neutral

soils (*p*H 6·8–7·1); alkaline soils (*p*H 7·2–7·9). Each group included four soils and was thus tested on twenty-four '*Aerobacter* circles'. The influence of the soil reaction on the number of Myxobacteria that developed is shown by the accompanying table.

DISTRIBUTION OF MYXOBACTERIA IN SOILS OF VARYING *p*H (24 REPLICATE '*Aerobacter* CIRCLES' TESTED)

*p*H of the soil group	Number of '*Aerobacter* circles' in which have grown		
	Myxococcus virescens	*Myxococcus fulvus*	*Chondrococcus coralloides*
4·1–5·5	3	0	7
6·8–7·1	13	1	10
7·2–7·9	17	4	3

In a laboratory experiment, *Myxococcus virescens* was found to have its optimum *p*H about 7, its activity decreasing very rapidly on the acid side and more slowly on the alkaline side[2]. The distribution in field soils thus agrees with the results of this experiment. Concerning the other two species no clear differences were shown. The decrease in number of *Chondrococcus coralloides* and the increase of *Myxococcus fulvus* is suggestive; but pure cultures of these species must be tested before any definite conclusion can be drawn.

My stay at Rothamsted Experimental Station was made possible by a grant from C. F. Liljewalch's Stipendiefond, University of Uppsala. I wish to express my thanks to Dr. H. G. Thornton for giving me facilities to work in his department and to Dr. B. N. Singh for guidance and advice in this work.

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Sept. 5.

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ROCKEFELLER FOUNDATION

REVIEW FOR 1949

IN a review for 1949 of the work of the Rockefeller Foundation*, the president, Mr. Chester I. Barnard, points out that political changes have prevented the Foundation from operating in Poland, Czechoslovakia, Hungary and China, in which it was formerly active. Moreover, although until recently the Foundation was a principal source of funds for foreign student fellowships at the advanced level, appointments now made annually by the Foundation constitute scarcely two per cent of the 15,070 comparable awards now offered, of which 62·5 per cent are by government agencies. Together with that of the General Education Board and of the Carnegie Corporation, the income of the Foundation is now less than one per cent of the budgetary needs of the 1,800 institutions now ministering to higher education, as against more than 15 per cent when the Foundation was launched in 1913. In the first part of the report the president discusses the comparatively modest yet significant part which a privately endowed philanthropic organization can play under present world conditions. Income in 1949 was 10,984,000 dollars, and net appropriations amounted to 10,276,525 dollars. Annual income from present assets is expected to average 8 million dollars; but the Trustees have reaffirmed the policy of using principal up to a level of two millions annually for projects of exceptional significance the needs of which can be met only through the Foundation.

In education, the Board of Trustees has decided to limit its programme to the advancement of education in the southern States, apart from assisting certain projects rendering broad, general services to education, such as the Commission on Financing Higher Education of the Association of American Universities, the Conference Board of the Associated Research Councils and the American Council on Education. The Commission was granted 4,000,000 dollars in 1949 towards a three-year study, while the Conference Board received a further grant of 120,000 dollars for a two-year study of the nation's human resources in relation to the needs in the fields of higher learning.

This new policy was adopted to avoid the excessive discrimination which a highly selective distribution in this field would involve; but the Board is well aware of the value of small grants and in general looks for opportunities which will be strategic in terms of human welfare rather than necessarily involving large sums of money. Moreover, as Mr. Barnard emphasizes, although there are some scientific activities which require great capital outlays or large groups of workers, in the research field it is the small and successful plantings which most frequently lead to new forests. The chance of eventual success is increased if a limited initial input is followed by increasing support based on a record of achievement, and Mr. Barnard indicates how the Foundation throughout its history has developed scientific leadership in this way. The ten thousand fellowships, aggregating twenty-five million dollars, which the Foundation has awarded during the past thirty-five years represent investments in intellectual capacity, imagination and character and, in particular, have contributed to the remarkable progress in public health during the past twenty-five years.

Referring to the scheme set forth in the 1948 report for the comprehensive study of problems of population, communication and co-operation, Mr. Barnard states that the phrase 'human ecology' has now been adopted in place of the narrower term 'population', as more descriptive of the range of problems in which the officers of the Foundation are seeking to discover gaps in interest and research in the academic world. The meaning of the word 'communication' has also been misunderstood, and Mr. Barnard points out that it embraces all those aspects of the broad problem of human communication which break down the dividing lines between the conventional disciplines and bring to light new fields for exploration. Natural science, medical science, social science and humanism can no longer exist in separate and self-contained spheres, and the new ties between them make for a more vital understanding and perhaps even mastery of the world of knowledge as a whole. Furthermore, while the Foundation was established originally on the premise that the welfare of mankind could be advanced through an increase in knowledge, it has become more and more clear that the most important knowledge is that which concerns human beings, and that the key to the attainment of dignified and rational existence for all men depends essentially upon a

* The Rockefeller Foundation: a Review for 1949. By Chester I. Barnard. Pp. 85. (New York: Rockefeller Foundation, 1950.)

vastly improved understanding of human behaviour, to be achieved by a synthesis of effort to which all disciplines contribute.

It is the policy of the Foundation to stress activities that promise to increase man's understanding of himself, and examples are cited of growing co-operation of the sciences and the humanities in common problems. One such venture, the Mexican agricultural programme, which in six or seven years has led Mexico well on the way to self-sufficiency in the production of corn and other staple foods, has led to an invitation to lend technical leadership to a Columbian programme in agriculture. The Sardinian malaria control campaign promises to wipe out the malaria problem of that island, and, after three years of intensive work towards which the Foundation will have contributed 375,000 dollars by the end of 1950, malaria is no longer a threat in Sardinia. An invitation from the Greek government to survey socio-economic conditions in Crete was accepted, and it is hoped that the survey will indicate the most strategic and helpful points of attack in any programme of economic development.

Two major grants of the Foundation in 1949 were for additional studies of the Near East. One, of 83,000 dollars to the American University of Beirut, was for interpretative studies of the life, thought and tradition of the modern Arab Middle East. The other provided 25,000 dollars to the American Board of Commissioners for Foreign Missions for studies of intellectual and cultural movements in modern Turkey. A number of grants were made for studies of interpersonal and intergroup relations. Of these, one to the Laboratory of Social Relations at Harvard University provides for a comparative study of the value systems of the Navaho and four other culture groups. At Yale University, members of the Institute of International Studies are studying the conditions essential to a more extensive international consensus, or voluntary accord, and the means of achieving it, while assistance has also been given to the University of Notre Dame for its research programme in international relations and to the Institute of Industrial Relations of the University of California for a study of the social, political and economic impact of an ageing population on American society. The Institute for Personality Assessment and Research at Harvard University was also established in 1949 with the aid of a three-year grant of 100,000 dollars from the Foundation, while a three-year grant of 121,200 dollars was also made in 1949 to the Tavistock Institute of Human Relations.

The Foundation has provided 50,000 dollars, available until the end of 1951, for the Institute of Andean Biology for equipment, and the new knowledge of high-altitude physiology that is expected to emerge from the research at the new Institute should contribute not only to progress in aviation but also in the treatment of disease. An outstanding feature of the year was the discovery in work on yellow fever by the Foundation's research staff in East and West Africa, Brazil and Columbia of a group of eighteen tropical viruses, of most of which very little is known. An international survey to determine the geographical distribution of these viruses is planned, and their physical properties and chemical components, the responses to them in animals, the immune responses and cultivation of the viruses in chick embryos are all being investigated, with the view of relating the viruses to each other or to known agents, establishing criteria for laboratory diagnosis of each infection, and determining how the viruses enter the body and what kind of damage they do. Already, however, it can be said that the Foundation's thirty-five years of work in this field have yielded a good understanding of the epidemiology, diagnosis and prophylaxis of the disease. Effective control measures are now available wherever and whenever yellow fever again invades urban populations.

The number of applications to the Foundation for aid again increased, and in 1949 3,017 were declined as compared with 2,702 in 1948, 2,510 in 1947, 1,839 in 1946 and 1,028 in 1945. Of these, 1,133 were for fellowships and travel and training grants. While many of the applications represented projects of interest to the Foundation which were declined because other opportunities seemed more promising, most of the applications that were declined fell outside the areas of work in which the Foundation is now attempting to be of service.

COLONIAL RESEARCH AND DEVELOPMENT*

THE Return of Schemes made under the Colonial Development and Welfare Acts records in detail how the sum of £13,361,281, twice the amount of the previous year, is to be expended in grants of £11,010,168, loans of £555,114 and research grants of £1,795,999 on the more than five hundred new schemes approved during 1949–50, of which 142 were for research. Schemes previously approved under the Act amounted to £56,821,426, with £6,219,908 for research schemes, thus, by March 31, 1950, more than half of the £120,000,000 authorized under the 1945 Act had already been earmarked for approved schemes. Agricultural development took up more than £2,000,000 of the expenditure last year —£1,949,991 for development and £113,608 for research. Water supplies and sanitation accounted for £1,046,720, primary and secondary education for £874,393, technical and vocational education for £657,634 and higher education for £934,637, training schemes for the Colonial Service for £501,527, forestry for £232,821, fisheries for £138,513, medical and health services for £632,258, physical planning and surveys for £673,752, roads for £1,177,956, medical research for £514,855, social research for £326,148, fisheries research for £290,918, and insecticides research for £241,465.

Of the research schemes, the largest two are £200,000 for the West African Virus Research Institute at Lagos, and £150,000 for the expansion and maintenance of the corresponding East African Institute at Entebbe, 1950–55. £137,000 goes for the maintenance for five years of an institute for research and training in fish farming at Penang, and £100,000 for the continuance for five years of the work of the Rhodes–Livingstone Institute in Northern Rhodesia, while £74,800 is provided for the establishment of the West Indies Institute for Social and Economic Research. £74,000 is provided for continuing the work of the East African Insecticides Research Unit for three years, £90,000 for continuing for five years the work of the Anti-Locust Research Centre, £76,000

* Colonial Development and Welfare Acts. Returns of Schemes made under the Colonial Development and Welfare Acts by the Secretary of State for the Colonies, with the concurrence of the Treasury, in the Period from 1st April 1949 to 31st March 1950. Pp. 73. (London: H.M. Stationery Office, 1950.) 1s. 9d. net.

for the establishment of an East African Marine Fisheries Research Survey in Zanzibar and £53,000 for the establishment of a West African Institute of Social and Economic Research. The establishment of a Fisheries Research Organization to serve Northern Rhodesia and Nyasaland receives £62,000, and £55,000 is provided for the establishment of headquarters in Tanganyika of the East African Insecticides Research Unit, £65,000 for experiments with the dissemination of insecticides from fixed-wing aircraft, £31,912 for research on bananas, soils, cocoa, and sugar technology at the Imperial College of Tropical Agriculture, a further £30,300 for the establishment of the Colonial Microbiological Research Institute, £47,000 for the formation of a filariasis research unit in East Africa, £19,500 for establishing an East African Malarial Unit, £10,500 for the construction and equipment of an East African Herbarium at Nairobi, and £16,616 for the establishment of a Tsetse Fly Research Unit in Northern Rhodesia. Supplementary capital provision for the East African Agriculture and Forestry and Veterinary Research Organizations amounts to £21,000; besides £14,955 for the investigation of the incidence of loiasis in the British Cameroons, £9,300 is provided for capital expenditure on research on the incidence of loiasis in Nigeria. Hot-climate physiology research in Nigeria receives £11,839, fundamental insecticides research at University College, Ibadan, £7,000, and the establishment and maintenance for five years of an Institute of Educational Research to serve Fiji, the British Solomon Islands Protectorate and the Gilbert and Ellice Islands, £21,017. A grant of £18,813 is for assistance towards the expansion and operation of the Elini Livestock Experimental Station, British Guiana, and one of £17,600 for research to ascertain causes of the swarming of the Moroccan locust and the best means of prevention; £20,000 is provided for the formation of a small pool of entomologists to undertake short-term investigations in the Colonies, especially in smaller territories which have no government entomologists on their establishments. Other miscellaneous grants provide for six postgraduate studentships for two years training in insecticides research, for fundamental research on Colonial insecticide problems at Rothamsted Experimental Station and at the Field Station of the Imperial College of Science and Technology, for Colonial medical research studentships, for the appointment of Colonial liaison officers at the Pest Infestation Laboratory and the Road Research Laboratory of the Department of Scientific and Industrial Research, and for research at the Lister Institute of Preventive Medicine into the preparation of precipitin sera for entomological investigations of malaria, trypanosomiasis, etc.

Nor does this indicate the full extent of the demands now being made by the Colonial Development and Welfare Schemes on the resources of Great Britain both in finance and in man-power. Besides the schemes listed specifically as research schemes, such general schemes as the desert locust survey and emergency control measures and the establishment of a malarial unit must also make appreciable demands on scientific man-power and on finance. Only a few of such schemes can be mentioned here, but the development plan for Uganda for which £697,000 is allotted, the control of 'sudden death' disease of cloves in Zanzibar (£193,000), the livestock diseases survey in Nyasaland (£39,970), geological surveys in Northern Rhodesia (£67,600), Bechuanaland (£23,340), Cyprus (£46,000), North Borneo and Sarawak (£107,650), Gold Coast (£21,200), the control of yaws in Jamaica (£45,512), tsetse control in Northern Nigeria (£355,960), the development of water supplies in Malta (£536,800), are schemes which sufficiently illustrate the variety and magnitude of the demand they make on the resources of Great Britain. This is quite apart from what is involved in such grants for higher educational development as that of £332,821 for the first stage of development of the permanent University College at Ibadan, Nigeria, the miscellaneous grants for the University College of the West Indies, including £207,000 for the construction of permanent buildings, £565,834 for the construction and equipment of a new technical college for the Federation of Malaya, £82,917 for an agricultural experimental station at Trinidad, and the £58,638 for completing the building programme of the Imperial College of Tropical Agriculture. The numerous grants for the Colonial Service training schemes, for agricultural development, fisheries development, forestry, road development and the Caribbean Medical Centre and the Suva Medical Centre, Fiji, all likewise represent a considerable contribution both of scientific manpower and of financial resources the magnitude of which is probably not generally appreciated, but may well bring a rich return to Great Britain as well as to the Colonial peoples.

GOLD MEDAL OF THE ROYAL ASTRONOMICAL SOCIETY

AWARD TO PROF. J. STEBBINS

LAST year the Gold Medal of the Royal Astronomical Society, which had been awarded to Prof. Joel Stebbins, was presented to Dr. C. S. Piggott, scientific attaché to the American Embassy in London, acting as proxy for Prof. Stebbins, who was unable to be present. Prof. W. M. Smart, president of the Society, delivered a presentation address which described the work of Prof. Stebbins and his specialization in photometric observations of practically every class of celestial bodies except meteors and planetary nebulæ. This address by the president has been published in full (*Mon. Not. Roy. Astro. Soc.*, 110, 2, 179; 1950).

Soon after going to Urbana Observatory in the University of Illinois in 1903, Prof. Stebbins commenced experiments with selenium cells, some of which he made himself, but the Dutch firm of Giltay, at Delft, produced the most satisfactory one. The first successful observations were made on the moon, and Prof. Stebbins found that the light of full moon is 0·22 candle-metres. At half-moon during the first quarter, the brightness is only 12 per cent of that of the full moon, and at last quarter it is reduced to 10 per cent. This is due to the irregularities of the lunar surface, the dark seas covering a large portion of the sunlit area during the last quarter. During a partial eclipse of the moon, he found that the instant of minimum light took place within 0·6 min. of the time predicted by the ephemeris. The selenium cell was also used to determine the light-curve of Algol, with very satisfactory results. For the first time the secondary minimum was observed, and the discovery at the same time of a continuous variation on either side of the secondary minimum suggested that the

fainter component *B* has an axial period of rotation equal to its orbital period of revolution with respect to the brighter component *A*. In addition, the hemisphere of *B* exposed to the radiation from *A* is brighter than the other hemisphere; this was the first time that this 'reflexion effect' had been observed. When Stebbins took up the study of Algol ten years later, using the more accurate photo-electric photometer, not only were the general features of the binary as determined with the selenium cell confirmed, but also another effect arising from the slightly ellipsoidal shape of the components was detected.

Algol, however, was one of the exceptions to Eddington's mass-luminosity relation on the assumption that the mass of *A* was 0·37 that of the sun and the mass of *B* half that of *A*. Later, when McLaughlin and Rossiter, using a new method, applied it to the solution of the binary problem, it was found that *A* was five times as massive as *B*, and *A* then satisfies the mass-luminosity requirements, thus vindicating the accuracy and importance of Stebbins's work.

At the total solar eclipses of 1918, 1925 and 1937, Stebbins measured the integrated light of the corona with his photo-electric apparatus, and concluded that there is little evidence of any noticeable variation of the total light of the corona during the sunspot period. Another interesting result was that the light of the corona, photo-electrically, is about one-half that of the full moon. From the absence of evidence of the Rayleigh scattering, it was inferred that the continuous and Fraunhofer spectrum can be produced by electrons or large dust particles, but not by atoms, molecules and particles of wave-length dimensions. Finally, over a large range of wave-lengths the intensity distributions for the sun and corona are the same—a fact which must be taken into consideration by all who formulate any general theory of the corona.

It is impossible to refer to all the branches of Stebbins's work, and it will be sufficient to mention one or two others of outstanding importance. In 1930, when he visited Lick Observatory, he turned his attention to an extensive observational programme on stars (starting with *B* stars), globular clusters and extragalactic nebulæ. This programme was so comprehensive and so important that it is well worth reading Prof. Smart's address to realize the implications of some of the results obtained. It may be mentioned that the evidence obtained from the globular clusters led to a revision not only of their individual distances but also of the diameter of the galaxy, which was shown to be considerably less than that of Shapley's original estimate and is now believed to be about 100,000 light-years or less. This reduction in the dimensions of our galaxy, combined with Stebbins's work on the Andromeda nebula with the photo-electric observations of its outlying regions, which showed it to be considerably larger than was originally believed, has led to the conclusion that there is little difference in the overall dimensions of the two systems.

In 1947 Stebbins attempted to locate the central nucleus of the galaxy. Using the 60-inch telescope at Mt. Wilson, the galvanometer deflexions for the infra-red filter (10,300 A.) and also for a red filter (7,190 A.) were noted in narrow zones, with the telescope stationary, in the neighbourhood of 326° galactic longitude. The observations extended over several degrees in longitude and latitude, and the maxima of the infra-red readings appeared to indicate a bulge. An analysis of the space-reddening showed that the light of the bulge, extending over 8° in longitude and 4–5° in latitude, when corrected for absorption, is comparable with the light of an equivalent section of the Andromeda nebula. The position, outline and total light of the bulge suggest that something is being detected near the galactic centre, but Stebbins makes no greater claim than this.

Prof. Stebbins's work is well summed up at the end of Prof. Smart's address: "In surveying our Medallist's work over the long period of nearly fifty years one cannot but be impressed by his devotion to one great department of astronomy which he in great measure has made his own, by his observational skill, his attention to detail and his critical analysis of the new and unexpected phenomena which his observations have brought to light".

INSTITUTION OF GAS ENGINEERS

AUTUMN RESEARCH MEETING

THE sixteenth autumn research meeting of the Institution of Gas Engineers was held in London during November 28–29, 1950, with Mr. F. M. Birks as president.

Like other public services, the gas industry has problems of peak load, if of less intensity. Normally they are met by the use of carburetted water gas, a product which makes the combined use of gasified coke and mineral oil. H. Stanier and J. B. McKean described a new process based on the gasification of mineral oil, blended with steam and heated in contact with a suitable catalyst. Under suitable conditions the product is a gas of composition and character similar to normal town's gas, and can be used for supplementing the latter at peak periods. From economic considerations this process might provide an alternative to gas manufactured from coal.

At the present time, the sulphur available from home sources is obtained by the purification of coal gas. The normal methods of recovery, although efficient, have certain practical difficulties, and any improved means might be an important contribution to the national economy. E. Johnson described an attempt to recover sulphur of high purity from the spent oxide of gas purification practice using a fluidized technique and solvent extraction. A sulphur product of 95 per cent purity is obtained, and the extracted oxide has a reactivity to hydrogen sulphide not greatly different from that of the original material. The work has shown that a semi-continuous process for the extraction of sulphur from spent oxide in a fluidized bed by means of solvents is possible, and no fundamental difficulties are likely to be encountered in making the process fully continuous. A large-scale fluidized process was proposed for further investigations.

The importance of combustion research in gas utilization was emphasized by J. E. Garside in a review of the field of relevant research. Flame propagation, flame stability, mechanism of combustion reactions, heat and energy release, heat and energy transfer, and ignition of gas–air mixtures were all briefly dealt with, and the extent of present-day knowledge indicated. Some of the major questions facing gas utilization in the industry at the present time were stated, and an attempt was made to answer them by explaining the findings of current researches in Great Britain and correlating those findings with the results of similar projects overseas.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

A Flying-spot Microscope

SURPRISINGLY little of the information obtained with microscopes has been quantitative; most observers are content to sit at the microscope and regard the image, or to photograph it. Theoretically, it is possible to scan the image or its photograph mechanically; but this has seldom been done in practice. The whole method of obtaining resolution by lenses involves so much loss of light, lack of control of contrast, and other difficulties, that it is difficult to provide a good display or method of scanning.

Some of these difficulties can be avoided by using a wholly different means of obtaining resolution and amplification. The essence of the problem of resolution is to separate in some way the light passing through very close regions of an object. The conventional microscope does this by using refraction by lenses to separate the light from neighbouring regions. An alternative method is to use the lens system the other way round, namely, to produce a minute spot of light. Discrimination between neighbouring points is then produced by passing the light through them at different times by making the spot scan it. After passing through the preparation, the spot is made to fall on a photocell, with subsequent amplification and display as required. Such a flying-spot microscope depends on scanning different parts at different times, and will only give accurate information about objects that are stationary or moving only at a rate of a different order from that of the spot.

The method is based on the well-known technique of flying-spot scanning by two cathode-ray tube rasters locked together. In front of the eyepiece of a microscope is placed a tube providing a televizing raster of high brilliance and very short time-constant. The microscope objective thus produces a minute spot of light that scans the preparation to be examined. The amount of light transmitted is determined by the density of the specimen and is picked up by a multiplier photocell. The output of this is used for modulating the raster on a second cathode-ray tube, of projection type.

This combination of optical and electronic techniques provides all the facilities of conventional microscopy, with important additional advantages, among which are the following. (1) A projection display some three foot square and of brightness several foot-lamberts can be obtained. This method of display has substantial advantages, not only for discussion and teaching, but also for measurement and indeed for ordinary surveying of preparations. (2) Since the size of scanning raster can be continuously varied, there is less need for changing of objectives. (3) The brightness of the image is readily controlled. (4) Since the contrast is determined by the amplifier gain as well as by the density distribution, contrast can be made greater, or less, than in the original specimen, with obvious advantages in studying unstained, or vitally stained, or overstained specimens. (5) It should be possible to produce visible displays, with incident radiation of a wave-length of at least from 2,000 A. to 10,000 A. (6) The quantum efficiency of the photocell is greater than that of the photographic plate by at least 100 : 1 at 2,650 A., making it proportionally easier to avoid producing alterations in living specimens. (7) Resolution in the ordinary microscope is affected by the halation produced by interference between neighbouring particles. Since only one resolvable region is illuminated at a time, resolution should be substantially greater with the flying-spot than with the conventional microscope. This possibility has not yet been systematically explored experimentally. (8) Perhaps the most important of all advantages is the possibility of quantitative analysis. The output of the photocell has a voltage-time distribution known as a time series, and can therefore be analysed by well-known techniques to give histograms and spectrograms of the specimens. Particles could probably be counted and sized at a rate of a million per second.

The first model that we have built suggests that these advantages can be realized, and further development is being undertaken.

This work has been made possible by a grant from the Nuffield Foundation.

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Extra-Corticle Membranes and Layers of the Wool Fibre

IT has been shown[1] that peracetic acid renders wool freely soluble in dilute ammonia, except for a small fraction which appears as a tubular membrane. By prolonging both these treatments, it has been possible to obtain further evidence in support of the theory concerning the structure of the outer layers of the wool fibre put forward by Reumuth[2], Lehmann[3], Swerdlow and Seeman[4] earlier, Lindberg, Philips and Gralén[5], and Zahn and Haselmann[6] more recently.

Extracted wool fibres were fixed by means of a solution of methyl methacrylate to an open frame which would accommodate a microscope slide. They were then suspended in peracetic acid for five days. After washing they were immersed in ammonia for a further seven days. The remains of the fibres had an appearance rather like transparent soft elastic and were quite fragile.

Microscopic examination showed them to be membranes similar to those illustrated by Alexander and Earland[1]. In view of the strong evidence supporting the existence of an epicuticle membrane[6-8], I attempted to break this major membrane with micromanipulators, hoping that if I could dislodge such an epicuticle I would be able to see some trace of it. This actually happened. The operation of sliding this very transparent sheath off the comparatively bulky major membrane was a hazardous one, and it was only in three attempts out of several on each of a hundred fibres that success was achieved. Although it was invisible in a bright field, by using the phase-contrast microscope and the very minimum of illumination, the first example was seen. The micrograph of this involved a 30-min. exposure with a 23 Scheiner orthochromatic plate (Fig. 1). Later, a better result was obtained with a 30 Scheiner plate. In both these cases a thin membrane was removed from the part of the major membrane shown in the micrograph.

Fig. 1. Epicuticle membrane of wool fibre (phase-contrast micrograph. × 400)

The most outstanding feature of this demonstration is that on the original major membrane there was no appearance of scales, and yet the thin epicuticle membrane shows definite scale-shaped marks (Fig. 1).

In one or two of the fibres there were small sections where the major membranes did show scale marks. In these cases the scale marks exhibited some amount of birefringence, showing that there was definitely scale material present, probably because these patches had, for some reason, received a slightly lighter treatment. One of these fibres broke while being mounted on the microscope slide. It assumed a folded shape, demonstrating its thinness, but still showed the shapes of scales on its surface. Fig. 2 shows this fibre, using phase contrast and between crossed 'Polaroids'. Those scale edges which were more clearly defined in ordinary light showed marked birefringence. Repeated attempts were made to slide the outer sheath off the membrane, but in no case was it possible. This, of course, may have been due to the high probability against the mechanics of the process, but the remains, after these attempts, did not have the same appearance as those previously mentioned. The impression gained led to the conclusion that there was material below the outer membrane acting as an adhesive.

The results obtained are interpreted as follows. The membrane as depicted by Alexander and Earland[1] represents the sub-cuticle membrane[2,3,9,10] or *Zwischenmembran*[6]. In some cases there was evidence of a thin outer sheath, the 'epicuticle'[4,7,8,10]. Below this and above the sub-cuticle membrane is some material possessing considerable birefringence and which appears to constitute part of the scales. Although it is not possible to see anything as thin as the epicuticle with the optical microscope, with the phase-contrast microscope it is possible to see quite clearly differences of intensities representing only 300–400 A. It is such differences of intensity that are shown in Fig. 1. The outlines of the scales are visible most probably because of small amounts of endocuticle which may remain because it is chemically more resistant[5,9,10]. In Fig. 2 the birefringent edges are almost certainly endocuticle

Fig. 2. Sub-cuticle membrane showing birefringent scale marks (phase-contrast micrograph in polarized light; × 175)

It is evident that this treatment dissolves the cortex and the exocuticle and will dissolve some, if not all, of the endocuticle. The *Zwischenmembran* and the epicuticle appear to be completely unaffected.

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Potentiation of the Action of Histamine by Semicarbazide

ZELLER[1] has shown that semicarbazide inhibits histaminase. We have found that this substance, added to Tyrode solution, potentiates the action of histamine on the guinea pig's ileum. The lowest concentration at which semicarbazide clearly potentiates histamine is of the order of 10^{-9}. The optimum concentration is approximately 10^{-6}, when the size of the histamine contractions may be doubled. Very high concentrations depress the effects of histamine. Potentiation is rapidly established and readily reversible. The accompanying record shows that semicarbazide selectively potentiates histamine, but has no similar effect on acetylcholine. Semicarbazide alone produces no contraction of the ileum, and the potentiation is probably due to inhibition of histaminase. Eserine, which inhibits cholinesterase, potentiates the effect of acetylcholine on the ileum much more than that of histamine. Certain other inhibitors of histaminase also potentiate histamine. The most active compound hitherto found is 2-methyl-5-amino-methyl-6-amino-pyrimidine (B, pyrimidine) which we have obtained through the kindness of Dr. Bergel, of Roche Products, Ltd. This compound potentiates histamine in a concentration of 2×10^{-10}.

The intact isolated diaphragm of the rat destroys histamine when immersed in a solution containing the drug. If the outside concentration is similar to the concentration of histamine within the tissue, the amount of histamine in solution destroyed within 2–3 hr. is equivalent to that contained within the tissue. The normal tissue histamine is not destroyed under these conditions, being apparently not available to the enzyme which destroys the histamine in solution. Semicarbazide (10^{-3}) completely inhibits the destruction of histamine by the isolated diaphragm.

It has been previously shown that D-tubocurarine potentiates the effect of histamine on the ileum[2]. We

Contractions of the isolated guinea pig ileum with constant submaximal doses of histamine (*H*) and acetylcholine (*A*) added alternately. Addition of semicarbazide (SC) to the bath fluid (concentration, 10^{-2}) potentiates the effects of histamine but not those of acetylcholine

have found that this potentiation only occurs if the D-tubocurarine is injected together with, or only shortly before, the histamine, and not if it has been in contact with the tissue for some time. The mechanism of potentiation in this case is probably different from that of semicarbazide, and appears to be due to a release of histamine from the tissue.

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Action of Thrombin in the Clotting of Fibrinogen

In spite of much literature on the clotting of blood, the exact mechanism of the final event, the mode of transformation of soluble fibrinogen to insoluble fibrin by the action of thrombin, remains unknown. The concept of thrombin as a hydrolytic or proteolytic enzyme[1,2] has fallen into disfavour[3], and in recent years other plausible but unproved mechanisms have been proposed[4–6]. In a study[7] of the proteins of the keratin–myosin–fibrinogen group by end-group assay with fluorodinitrobenzene[8], only small amounts of terminal amino-groups could be detected in fibrinogen, although the amounts were not sufficiently small to conclude, as in the case of myosin and tropomyosin, that the molecule is constructed of *cyclo*-peptide units. The action of purified thrombin, however, results consistently in the appearance of amino-terminal residues of glycine, and whatever the ensuing mechanism, we believe that the fundamental enzymic step in the transformation of fibrinogen to fibrin is associated first with the appearance of these groups. This action of thrombin, which tentatively may be considered as a very specific proteolysis, was discovered independently in Cambridge and in Leeds, and for this reason the relevant observations are reported jointly.

Cambridge. Fibrinogen prepared from ox blood by salting out with phosphate buffer[9] and reprecipitating three to four times was found to be 90–95 per cent clottable and to contain approximately one terminal mole of tyrosine and one of glutamic acid in 250,000 gm. of protein[7]; terminal residues of glycine were absent or negligible. After clotting, the purest samples contained one terminal mole of glycine in about 100,000 gm. of protein, which is of the order of five groups per mole of fibrinogen. Some samples of doubtful purity have contained rather less, but in every sample of fibrin examined terminal residues of glycine were detected. The action of thrombin seems specific for fibrinogen, since the incubation of proteins such as ovalbumin and myosin with the enzyme does not result in the liberation of new terminal groups. The objection may be raised that amino-groups of glycine are actually present in fibrinogen but are unreactive, the action of thrombin being to reveal them by denaturing the protein. This view is not supported either by the study of a denatured fibrinogen or by the application of treatments which generally enhance the reactivity of amino-groups[10].

Leeds. A three-fold approach to the problem was made:

(1) In order to make equal allowance for possible impurities, experiments in parallel were undertaken with purified ox fibrinogen and with the whole fibrin-plus-supernatant system obtained from it. Clotting was carried out with Hoffmann–La Roche thrombin, or Prof. Seeger's purest thrombin, kindly supplied by him; and in several experiments the clotting times were short and sometimes at 0° C., so as to lessen the possibility of non-specific hydrolysis. The fibrin was found always to contain considerable numbers of amino-terminal groups of glycine, whereas none, or very few, was found in fibrinogen.

(2) An attempt was made to isolate fibrin from any unchanged fibrinogen and from occlusions in the clot network by use of its solubility in urea[11]. The clot was dissolved in a 30 per cent (w/v) urea solution, from which the fibrin was then precipitated by the addition of physiological saline, and washed thoroughly with saline and water. The results with this material, considered to be pure fibrin, indicated approximately one terminal glycine per 140,000 gm. of fibrin. No other end-groups could be detected in appreciable amount, though glutamic acid was found at about one-tenth the glycine concentration, and occasionally still smaller quantities of serine and aspartic acid.

(3) Since there is no adequate criterion of purity for fibrinogen, several methods of purification were tried, and in all cases the clottability of the final product exceeded 90 per cent. The different preparations were then examined for α-amino groups; but, as mentioned above, no glycine end-groups (or only variable traces) could be found, and such positive indications as were observed may be ascribed to impurities or traces of fibrin. Other terminal amino-acids were detected, however, including aspartic acid, glutamic acid and serine; but whether these are derived from fibrinogen or from impurities is not yet decided.

Further evidence from the experiments as a whole suggests that during the course of clotting the number of glycine end-groups liberated can be used as an estimate of the amount of fibrin in the system.

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Effect of High Concentration of Phosphorus-32 on Growth of the Potato

Studies of the use of phosphorus-32 for the production of somatic mutations in the potato require a knowledge of the amount of active material which, as part of the nutrient solution, would produce toxic effects at the growing points. Further, the concentration of phosphorus-32 in the growing point must be known if an estimate is to be made of the radiation dose received. A knowledge of the dose received is essential in order to make comparisons of the effects produced with those resulting from similar doses of other types of ionizing radiation. In this communication, experiments with phosphorus-32 on three varieties of potato (Gladstone, Edzell Blue and Arran Pilot) are described.

The potato is characterized by variation in the form and development of the individual according to the environment of the parent plant and the nature and size of the piece of tissue used in propagation. The following method has been adopted so that the variation might be minimized and the residue analysed. Individual sprouts obtained from the chitted daughter tubers of six plants of each of the three varieties were planted in 800 gm. of acid-washed sand contained in waxed pots. The moisture content was 50 c.c. Some 960 rooted sprouts were obtained, which enabled any somatic variation, physiological or genetical, to be analysed.

No prior observations appear to have been reported on the toxic levels of phosphorus-32 in plants (that is, levels at which whole organs were killed as distinct from levels at which only the physiology of the plant was disturbed[1]). Two activity-levels were therefore employed. Amounts of 10 μC. and 100 μC. of phosphorus-32 per plant were given to separate batches of sprouts after they had been in sand for a week. The amounts were dispensed in 10 c.c. of a 0·002 molar solution of disodium hydrogen phosphate. At the time of potting the sprouts had been given a complete nutrient starter solution in which the normal phosphate-level was halved. All nutrient was thoroughly leached from the pots twenty-four hours before treatment. After treatment, the sprouts remained in the sand for a fortnight, during which a phosphate-free nutrient solution was given twice. The plants were then removed and potted singly into compost after washing the roots. At this stage there was no observable difference between the control plants and those treated at the 10-μC. level, but approximately 1 per cent of the plants treated at the higher level were showing abnormal growing points. The abnormalities were not sufficiently distinct to score at this time.

Samples of the batch treated with 100 μC. of phosphorus-32 taken at the end of the treatment period were analysed by wet digestion and the solutions counted in a liquid counter. The results of these measurements of the average concentration and total activity of phosphorus-32 in each of the three varieties are given in Table 1.

The variations in the measurement of different plants of the same variety are so great that the only varietal difference of possible significance apparent from the table is the greater concentration of phosphorus-32 in the Gladstone variety. The activities have been referred to the initial treatment-time; but it should be noted that the weight of the plants at this time was smaller than at the time of measurement. The average level of concentration during the first fortnight is therefore likely to be somewhat higher than is indicated by Table 1.

In each case the growing point was dissected from the plant and the concentration of phosphorus-32 in it

Potato variety Gladstone, showing the difference between (left) normal and (right) blind shoots from 100-μC. treatment. ½ natural size

Table 1. Uptake of Phosphorous-32 after Treatment with 100 μC.

Variety	Total activity (μC.)	Initial concentration (μC./gm.)	Residue in sand (μC. per pot)
Gladstone	23·7 ± 4·5	1·78 ± 0·20	4·5
Edzell Blue	21·4 ± 1·5	1·23 ± 0·18	4·5
Arran Pilot	17·5 ± 4·2	1·18 ± 0·11	8·0

Time-table: Sprouts potted in sand, 19.5.50; treated with 100 μC. phosphorus-32, 30.5.50; samples taken for analysis, 12.6.50.

determined separately. This concentration was found to be approximately six times greater than the average concentration of phosphorus-32 in the whole plant. Again there appeared to be no significant difference between the three varieties.

An estimate of the radiation dose received by the growing point may be made in the following manner. It is well known[2,3] that for media of extent greater than twice the range of the beta-particles (that is, for phosphorus-32, thicknesses greater than about 1 cm.) the dose throughout a tissue medium is about 800 r. for a concentration of 1 μC./gm. of phosphorus-32 completely destroyed. This dose falls, near the edges of the medium, to a value at the surface of one-half the maximum dose. If the medium is less thick than twice the range of the beta-particles, the maximum dose at its centre is less than that calculated above and varies in a known manner[4]. The tissue, including leaf initials, surrounding the growing point was found to have an average thickness of about 0·4 cm., for which the maximum dose at the centre of the growing point would be[4] 680 r. for 1 μC./gm. of phosphorus-32 completely destroyed. Assuming an average concentration of 1·5 μC./gm. per plant (see Table 1) and a ratio of six times for the growing point (that is, 9 μC./gm.), the total dose received by the growing point would be 6,000 r. The range of variation is probably from about 4,000 r. to 8,000 r. It should be noted that since the half-life of phosphorus-32 is 14·3 days, half the calculated dose will be received in the first fortnight. It may well be that the dose in this fortnight is a more significant quantity than the total dose, for in the calculation of the latter it is assumed that the concentration of phosphorus-32 remains unaffected by the subsequent conditions of growth.

When the plants had developed a satisfactory root system in compost, they were set out in the field and allowed to grow to maturity. By the end of July (that is, two months after treatment) several abnormalities were visible in the treated plants. These abnormalities included increased fleshiness of the leaves, loss of secondary leaflets, and increased branching compared with normal plants. The most striking difference was, however, the appearance of blind plants in which the main shoot terminated in three leaves surrounding an aborted growing point. The term 'blind' is adopted as the appearance is very similar to blindness in cauliflowers. This condition is illustrated in the photograph, and the frequency with which it occurred is shown in Table 2. In normal plants the growing point is still viable when the rest of the plant is yellowing at maturity or has terminated in a flower truss.

Table 2. Percentage of Blind Plants

Variety	Control	10-μC. treatment	100-μC. treatment
Gladstone	0·0	10·9 ± 4·6	68·0 ± 7·3
Edzell Blue	0·0	0·0	41·9 ± 4·3
Arran Pilot	0·0	0·0	51·5 ± 6·4

From Table 2 it would appear that varietal differences in resistance to damage probably occur, although to what extent the production of blind plants is dependent on the uptake of phosphorus-32 is not certain from these experiments.

These experiments show, however, that about 100 μC. of phosphorus-32 must be administered to potatoes in this fashion in order to produce observable effects. Of this 100 μC., about 20 per cent appears to be taken up by the potato plant under these conditions. The concentration of phosphorus-32 in the growing point appears to be about six times that of the average concentration-level in the plant, and doses of the order of 3,000 r. are received by the growing point in the first fortnight following treatment with 100 μC. of phosphorus-32.

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Antitumourigenic Action of Steroids as an 'Independent' Faculty of these Compounds

As the power of steroids to prevent œstrogen-induced abdominal fibroids decreases with[5] their diminishing progestational activity (progesterone → deoxycorticosterone → testosterone), we assumed, in an earlier phase of our work, that antifibromatogenic activity is correlated with the progestational one[1]. Whereas the finding that the non-progestational Δ^{16}-dehydroprogesterone was not antifibromatogenic seemed to substantiate this assumption, subsequent statements of ours were contrary to it. It has long been known that substitutions at C_{17} considerably increase the progestational activity of testosterone[3]; however, when ethinyl-, ethyl- and vinyl-testosterone were tried in our work with fibroids, they were found to be not more, and often even less, antifibromatogenic than testosterone[3,4]. Similarly, there was no correlation between androgenic and antifibromatogenic activities. Neither was there any correlation between cortical and antifibromatogenic activities. Pregnenolone-3-acetate is much inferior to 21-acetoxypregnenolone in maintaining alive the suprarenalectomized guinea pig[5]; however, very large quantities of the former prevented the formation of fibroids, whereas this was not the case with similar quantities of the latter[6]. Thus we reached the conclusion that antifibromatogenic activity is a faculty *per se*, not a sequel of any known, or classical, physiological action of the respective steroids[4,7]. It is not 'subordinate' to progestational action; it is an 'independent' action, to use Selye's[8] terminology.

On the other hand, it must be pointed out that all antifibromatogenic steroids are 3-keto compounds[1]. Pregnenolone-3-acetate is the only compound with OH at C_3 which shows antifibromatogenic activity,

and then only when more than 30–50 times the progesterone threshold is given[4].

In the meantime, Masson and Selye stated that methyl-androstanediol and especially methyl- and ethinyl-Δ^5-androstenediol are progestational; their activity is not inferior, if not superior, to that of, for example, methyldihydrotestosterone[9]. In this connexion the androstanediol and androstenediol derivatives are exceptional among steroids with OH at C_3. We believed that similar compounds should offer an excellent opportunity of examining the question whether acquisition of progestational action would mean also acquisition of antifibromatogenic powers. The non-substituted androstenediol is without, or almost without, progestational action (ref. 10, comp. No. 13) and it is also without antifibromatogenic action[11] (see also ref. 12, p. 138, comp. No. 20). Will antifibromatogenic action be acquired by this compound by a substitution at C_{17}, as progestational action is?

Experiments. The trials were made in the usual way. Tablets of α-œstradiol were implanted beneath the skin of castrated female guinea pigs; tablets of ethinyl-androstenediol (m.p. 243°) or methyldihydrotestosterone (m.p. 191°) (melting points determined by Dr. F. Fuenzalida, biochemist of this Department) were implanted on the other side of the same animal. Absorption of the former is very slow; only $0{\cdot}6 \pm 0{\cdot}06$ μgm. per day was absorbed per 1 sq. mm. of a tablet, as against $2{\cdot}7 \pm 0{\cdot}2$ μgm. of the latter. One to six tablets had to be implanted so as to obtain a convenient range of absorption of ethinyl-androstenediol in a group of twenty animals. Results with ethinyl-androstenediol and œstradiol were compared with those in a group of eight animals with œstradiol only, and to a group of twenty-four which received methyldihydrotestosterone and œstradiol. Classification of the fibrous tumour effect was made in arbitrary 'units', according to rules followed for some years in our work[13–16].

With œstradiol alone (average absorption per day 4 μgm.) an average fibrous tumour effect of 3·8 was obtained. With the simultaneous absorption of methyldihydrotestosterone, this figure decreased parallel with the quantity absorbed per day. The antifibromatogenic action of methyldihydrotestosterone became evident with an average dose of 103 μgm. per day; at 160 μgm. per day, the fibrous tumour effect was 1·7, decreasing to 0·8 when 223–453 μgm. per day were absorbed. On the other hand, no decrease of the fibrous tumour effect was obtained with ethinyl-androstenediol even when as much as 185–450 μgm. per day was absorbed simultaneously with œstradiol.

Increase of uterine weight due to œstradiol also was counteracted to a certain degree by methyldihydrotestosterone, especially with larger quantities of the latter. Genital bleeding, which occurs when œstradiol alone is given, was prevented by methyldihydrotestosterone but not by ethinyl-androstenediol.

The results with ethinyl-androstenediol are clear: acquisition of progestational power by a non-progestational steroid through a substitution at C_{17} does not mean acquisition of antifibromatogenic activity. Two compounds such as ethinyl-androstenediol and methyldihydrotestosterone, which are equally progestational, differ entirely as to their antifibromatogenic activity. Our conclusion that antifibromatogenic action is an *independent* action of certain steroid compounds, preferably of a small group of 3-ketosteroids, remains, therefore, unchanged.

Recently there has been in different countries much outstanding work with steroids in the treatment of benign and malignant tumours (see tabulated summary in ref. 12, pp. 161–162). For further progress in this field, it seems fundamental to realize that antitumourigenic action is not subordinated to any other known activity of steroid compounds.

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Distribution of the Fatty Acids in the Liver Lipids of the Horse

In the liver lipids of animals which have so far been examined it has been found[1] that the phospholipids, as compared with the glycerides, contain less hexadecenoic acid but more stearic and highly unsaturated C_{20} and C_{22} acids, the latter being derived from dietary linoleic and linolenic acids[2]. Phospholipids, moreover, are generally regarded as selecting the more highly unsaturated acids from the diet[3].

The animals which have hitherto been used for the study of the fatty acid composition of the liver lipids have either been of the type which do not store linolenic acid (heterolipoid[4]) or else they have not had access to substantial amounts of this acid in the diet. We thought it of interest, therefore, to study the liver lipids of the horse, as this animal has been shown to store linolenic acid readily in the depot fats[5]. In the work now reported, the animals used had been fed solely on pasture, the main fatty constituent of which is linolenic acid.

The difference between the glycerides and phospholipids of the horse liver in respect of hexadecenoic, stearic and highly unsaturated $C_{20}-C_{22}$ acids are shown in Table 1 to conform with those previously found for other animals. The generalization, however,

Table 1. Composition of the Liver Lipids of the Horse

	Fatty acids (weight per cent)								
	Saturated				Unsaturated				
	C_{16}	C_{18}	C_{19}	C_{20}	C_{16}	C_{18}	C_{18}	C_{20}	C_{22}
Glycerides	1·7	25·2	5·3	—	1·6 (−2·0H)	8·3 (−2·0H)	52·8 (−4·5H)	3·4 (−6·2H)	1·7 (−6·0H)
Phospholipids	—	10·8	20·7	4·6	—	2·0 (−2·0H)	50·6 (−3·4H)	10·4 (−5·7H)	0·9 (−5·7H)

that the phospholipids select preferentially the more unsaturated acids is an over-simplification, as shown by the composition of the C_{18} unsaturated acids (cf. Table 2), determined by the alkali isomerization technique of Hilditch, Morton and Riley[6].

Table 2. Percentage Composition of the C_{18} Unsaturated Acids

	Octadecatrienoic (linolenic)	Octadecadienoic	Oleic (by difference)
Glycerides	47·8 (43·2)*	19·1	33·1
Phospholipids	8·1 (6·3)*	60·8	31·3

* Determined by the hexabromide method of White and Brown (ref. 7).

It is apparent that the highly unsaturated linolenic acid, contrary to expectation, is present in much greater proportions in the glycerides of the horse liver than in the phospholipids of the horse liver, while octadecadienoic acid is present in much greater proportions in the phospholipids than in the glycerides, its concentration exceeding many times that found in the pasture lipids or in the depot fats of the horse.

It is thus clear that the selectivity of the phospholipids, at least in the horse liver, is not for highly unsaturated acids in general, but for specific unsaturated acids irrespective of whether such acids have been derived by direct assimilation from the diet or by synthesis from other acids by the animal.

Further investigations on the liver lipids of the horse and other animals are in progress, and it is intended to publish a full account elsewhere.

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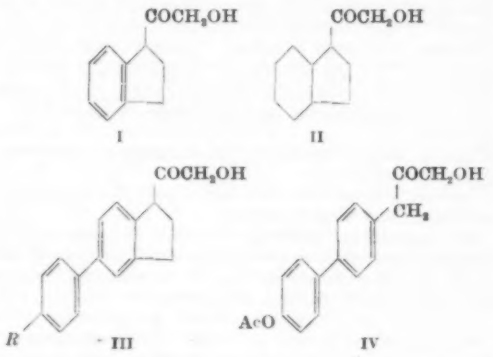
Synthetic Analogues of the Adrenal Cortical Hormones

The problem of synthetic molecules likely to possess physiological properties similar to the adrenal cortical hormones is being investigated in these laboratories. A number of such compounds have been prepared and examined, five of which have emerged showing significant activity. These compounds are indan-1-hydroxymethylketone (I), its fully saturated hexahydro analogue of unknown stereochemical orientation (probably *cis*) (II), 5-phenylindan-1-hydroxymethylketone (III: $R = H$, OCH_3) and *p*-acetoxy-*p'*-(*w*-hydroxy)acetonyldiphenyl (IV).



These materials were synthesized from the corresponding carboxylic acids by the method of Steiger and Reichstein[1].

Table 1

Substance	Melting point	Analysis			
		Found		Required	
		C%	H%	C%	H%
(I)	b.p. 101–102°/0·1 mm. pressure	75·8	6·5	75·1	6·8
(II)	99°	72·4	9·9	72·6	9·9
(III) $R = H$	36°	81·2	6·2	81·0	6·4
(III) $R = OCH_3$	84°	76·0	6·4	76·5	6·4
(IV)	93–94°	71·6	5·5	71·8	5·6

The life-prolongation tests were based on the survival under cold stress of bilaterally adrenalectomized young rats, the method being a modification of that due to Selye and Schenker[2]. Groups of six to ten animals of average weight 40–55 gm. were used at each dose-level of the substance under test, identical groups being used as controls, one group treated with DOCA and one left untreated. The results of a number of such experiments on compounds I and II are summarized in Table 2. Preliminary results only are recorded for compounds (III) and (IV).

In every case the corresponding acetoxymethyl ketones proved completely inactive.

Compounds (I) and (II) had no influence on the liver glycogen of adrenalectomized fasting mice, nor was any effect observed on the sodium/potassium metabolism in the rat.

The biological tests are due to Prof. G. A. H. Buttle and Dr. F. J. Dyer of the Pharmacological Department of this School (life-prolongation), Prof. J. Beattie and Mrs. Herbert of the Royal College of Surgeons (glycogen), and Prof. E. C. Dodds and Mrs.

Table 2

Substance	No. rats per group	Wt. of substance giving same response as standard		M.W.	No. moles cpd. equivalent to 1 mole DOCA	Mean
		Subst. (mgm.)	Standard (DOCA) (mgm.)			
(I)	5	3	0·33	176	17	16
	5	3	0·375		10	
	5	3	0·33		17	
	8–10	1	0·087		21	
(II) *cis* configuration ?	5	3	0·6	182	8·2	10·7
	6	2·5	0·5		3·9	
	6	2	0·5		7·2	
	4	5	0·418		21·7	
(III) R = H		1·25	0·25	252	6·6	
(III) R = OCH_3		1·25	0·5	282	2·9	
(IV)		1·25	0·5	282	2·9	

The error is of the order 100 ± 80 (P = 0·95).

Simpson (salt balance) of the Courtauld Institute of Biochemistry.

Full details of the chemistry and pharmacology will be published elsewhere.

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Structure of Adenylthiomethylpentose

It has been shown in a previous communication[1] that the structure of adenylthiomethylpentose is 9′-(5-thiomethyl-ribofuranosyl)-adenine, based on periodate titration of adenylthiomethylpentose, thiosugar and thiopentitol, and from the result of the Boeseken test upon adenylthiomethylpentose. We have now obtained further evidence for this structural formula using synthetic methods.

Adenylthiomethylpentose gave a tritosyl derivative (m.p. 158–160°. Found: N, 9·27; calc. for $C_{33}H_{33}O_9N_5S_4$: N, 9·21 per cent) on treatment with *p*-tosyl chloride in dry pyridine. Since none of its tosyl residue was replaced by iodine on treatment with sodium iodide in acetone during 2 hr. at 100°, it follows that there is no tosyl group at position 5 of the sugar portion.

Condensation of adenylthiomethylpentose with acetone in the presence of zinc chloride gave mono-*iso*propylidene adenylthiomethylpentose (m.p. 143°. Found: N, 19·9; calc. for $C_{14}H_{19}O_3N_5S$: N, 20·7 per cent. Picrate, m.p. 175°. Found: N, 19·76, S, 5·8; calc. for $C_{14}H_{19}O_3N_5S.C_6H_3N_3O_7$: N, 19·78, S, 5·66 per cent), from which the *iso*propylidene group was hydrolysed by dilute acid to give adenylthiomethylpentose again, though the yield was very poor.

On the other hand, monoacetone adenosine, obtained by condensing with acetone in the presence of zinc chloride by the method of Levene and Tipson[2], was converted to 5-tosylmonoacetone adenosine (found: N, 15·52; calc. for $C_{26}H_{29}O_6N_5S$: N, 15·18 per cent) by treating with *p*-tosyl chloride in dry pyridine at room temperature for 24 hr. Dry tosyl monoacetone adenosine and dry sodium methyl mercaptan was dissolved in acetone and the solution heated in a sealed tube at 100° for 2 hr. The reaction product (5-thiomethylmonoacetoneadenosine) after conversion into the picrate, which had a melting point of 172–174° (decomp.) (found: N, 19·3, S, 5·3; calc. for $C_{14}H_{19}O_3N_5S.C_6H_3N_3O_7$: N, 19·7, S, 5·6 per cent), was compared with the monoacetone derivative of the natural compound, and no melting-point depression occurred when admixed with the picrate of monoacetone adenylthiomethylpentose.

Also, from 5-tosyl-2,3-*iso*propylidene inosine[3] (m.p. 185°) 5-thiomethyl-2,3-*iso*propylidene inosine was obtained by heating with sodium methyl mercaptan in acetone. The crude reaction product was converted into picrate (m.p. 102° (decomp.); found: N, 16·4; calc. for $C_{14}H_{18}O_4N_4S.C_6H_3N_3O_7$: N, 17·2 per cent).

Treating adenylthiomethylpentose with nitrous acid gave hypoxanthinylthiomethylpentose (m.p. 221°) as described by Kuhn and Henkel[4], which yielded a monoacetone derivative (m.p. 85° (decomp.)) on condensing with acetone in the presence of zinc chloride. The picrate of the latter had a melting point of 105° (decomp.) (found: N, 16·75; calc. for $C_{14}H_{18}O_4N_4S.C_6H_3N_3O_7$: N, 17·2 per cent), and showed no melting-point depression when admixed with the picrate of the monoacetone-derivative of 5-thiomethyl-inosine.

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An Isomeric Benzylideneguanosine

Although various investigators[1] have prepared benzylideneguanosine, Michelson and Todd are the only ones who report a specific rotation as well as a melting point for this compound. Recently it became desirable to prepare benzylideneguanosine in this laboratory. Using the same general method described previously[1], we have obtained a benzylideneguanosine with a melting point in agreement with those already reported, but with a specific rotation which is quite different. On the other hand, benzylideneadenosine has also been prepared and has been found to be identical in physical properties with the substance described by Michelson and Todd[1].

Anhydrous guanosine from yeast nucleic acid (m.p. 235° C. decomp. (all melting points are uncorrected); $[\alpha]_D^{28}$ − 60·2° in 0·1 N sodium hydroxide*, c 3·05; $[\alpha]_D^{21}$ − 34·1° in dimethylformamide, c 0·122) was used as the starting material in the preparation of the benzylidene derivative.

* This specific rotation is for guanosine containing two molecules of water of crystallization; all other specific rotations given in this communication are calculated on an anhydrous basis.

Crude benzylideneguanosine was isolated in 74 per cent yield (m.p. 282–287° C. decomp.; $[\alpha]_D^{23}$ − 88° in 0·1 *N* sodium hydroxide, *c* 0·62). Contrary to the experience of others[1], repeated recrystallization from 70 per cent ethanol failed to yield an analytically pure product. On recrystallization from aqueous 'Cellosolve', however, one-third of the crude material was recovered as a crystalline product (rosettes of flat leaves). Recrystallization of this material from 70 per cent ethanol left the melting point and specific rotation unchanged. The properties of this sample are as follows: melting point, 301–2° C. (decomp.); $[\alpha]_D^{25}$ − 73·2° in dimethylformamide, *c* 1·413; $[\alpha]_D^{25}$ − 72·5° in pyridine, *c* 0·588 (a nearly saturated solution of our benzylideneguanosine in pyridine; Michelson and Todd's results indicate that their benzylideneguanosine is much more soluble in pyridine); $[\alpha]_D^{25}$ − 79·8° in 0·1 *N* sodium hydroxide, *c* 0·602. The analytical results are, furthermore, in good agreement with the values calculated for benzylideneguanosine (found, in material dried to constant weight *in vacuo* at 110°: C, 54·94; H, 4·52; N, 18·91; calculated for $C_{17}H_{17}O_5N_5$: C, 54·98; H, 4·62; N, 18·86 per cent).

The above data, in conjunction with those of Michelson and Todd[1], indicate clearly the existence of benzylideneguanosine isomers. Although the nature of this isomerism is not at present understood, several explanations are possible: (1) the isomerism may be due to the substitution of the benzylidene group in different positions on the nucleoside; (2) the isomerism may be due to the new asymmetric centre introduced by the substitution of a benzylidene group in guanosine. Further experiments are in progress to determine the structures of the isomers.

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Arylamine-N-glycosides

The study of amine-N-glycosides has been stimulated in recent years by the occurrence of this type of compound in nucleic acids and in certain co-enzymes. The present position is that, whereas the nucleosides are generally accepted as being N-furanosides, the structures of the simpler compounds of this type, such as aniline-N-glucoside (glucose anilide), have not yet been firmly established[1].

Aniline condenses with D-ribose under different conditions to give two distinct crystalline aniline-N-D-ribosides, one of which, it has been suggested, is a pyranoside, whereas the other is a furanoside[2]. However, as has already been pointed out[1], further evidence is necessary before the structures assigned to these compounds can be accepted. We have now shown that when aniline reacts with ribose in alcoholic solution the isomer which is obtained depends on the presence or absence of water. By heating aniline with ribose in anhydrous ethanol, we have invariably obtained isomer *A*, of melting point about 130°, $[\alpha]_D^{1.5}$ + 186°-(*c*, 0·8 in pyridine). If the reaction is carried out with moist ethanol there results isomer *B*, of melting point about 115°, $[\alpha]_D^{1.5}$ + 62° (*c*, 1·0 in pyridine). *A* is the furanoside of earlier workers[2–4], and *B* their pyranoside. Attempts to recrystallize *A* from moist ethanol give *B*; similarly, *B* is converted to *A* in dry ethanol. Although there are some discrepancies in the specific rotations of the two compounds as determined by different workers (see accompanying table), it is clear that in methanol, at least, the specific rotations of the two compounds change to approximately the same final value, which does not lie between the individual values. If the methanolic solution of constant specific rotation is allowed to evaporate to dryness in the laboratory atmosphere, the crystals deposited are *B* in every case.

The simplest explanation of this behaviour is that each of the two compounds *A* and *B* is converted in solution into an equilibrium mixture of *A*, *B* and the acyclic, Schiff's base type of compound. We have no evidence in support of the existence of this third form. The contrast in behaviour between the stable O-glycosides and the labile N-glycosides is very striking. This facile interchange of forms in solution, apparently general for arylamine-N-glycosides, renders inapplicable most of the chemical methods normally used for elucidating structure. The use of infra-red absorption spectra measurements appears promising, but has not yet been widely investigated[4]. It is noteworthy, however, that all the characterized derivatives prepared from arylamine-N-glycosides have the pyranose ring system. For example, aniline-N-glucoside has been shown to yield, on acetylation, a mixture of α- and β-aniline-N-glucopyranoside tetra-acetates[1]. After many experiments, we have now been able to methylate aniline-N-glucoside under mild conditions with dimethyl sulphate to obtain 2 : 3 : 4 : 6-tetramethyl β-aniline-N-glucopyranoside in rather low yield. In addition, the two aniline-N-ribosides have been shown to give aniline-N-ribopyranoside tri-acetate[2,3], and β-aniline-N-galactoside is acetylated to the pyranoside tetra-acetates[4].

Although in many cases two crystalline isomers of the arylamine-N-glycoside have been obtained, this is not invariably true. Aniline-N-glucoside is known only as an amorphous solid, whereas *p*-toluidine-N-glucoside and aniline-N-galactoside have each been isolated in one crystalline form only, probably the β-pyranoside[1,5]. By using anhydrous conditions for the preparation of N-glycosides, we have been successful, in certain cases, in obtaining a new isomer. The case of *p*-toluidine-N-glucoside illustrates this. The only isomer previously known has melting point 117–118°, $[\alpha]_D$ − 101 → −46° (*c*, 0·5 in methanol), whereas the compound obtained using anhydrous ethanol has melting point 135–136°.

	$[\alpha]_D$ of *A*		$[\alpha]_D$ of *B*	
Ref.	In methanol	In pyridine	In methanol	In pyridine
2	Not given	+ 176·5° → + 156·6° → + 180° (dry solvent)	Not given	+ 63·4° → + 48·6° → + 60° (dry solvent)
3	Not given	+ 180° → + 161° (moist solvent)	Not given	+ 60° → + 48·4° (moist solvent)
4	+ 135° → + 12°	+ 182° → + 52·3°	+ 23° → + 13°	+ 62° → + 50°
Present authors	+ 171° → + 14°	+ 186°	+ 24° → + 10°	+ 62°
	+ 135° → + 14°			

$[\alpha]_D + 209 \rightarrow -45°$ (c, 0·6 in methanol), and is probably α-*p*-toluidine-N-glucopyranoside. In the same way we have obtained evidence for the existence of an aniline-N-galactoside distinct from the previously known one. It appears to be general, where two isomers have been obtained from the same sugar and amine, that their specific rotations in methanol change to the same final equilibrium value.

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The 'Turn Over' Transition of Suberic Acid

A lattice transition which is not induced by nuclei or boundaries but takes place simultaneously in the whole of a crystal by the jump of a whole lattice plane is termed 'turn over' (*Umklappen*). Such transitions are observed with certain metals (cobalt, thallium) and especially in the austenite - martensite transition. When, in 1941 in this laboratory[1], the phenomenon was discovered for the first time with an inorganic salt (potassium dichromate), we were informed by Prof. L. Kofler (Innsbruck) that a similar 'flashlike' transition can be observed with suberic acid crystals. The features of this 'turn over', as we have observed it, are described here.

Sufficiently pure suberic acid, molten between two cover glasses in a Leitz heating-stage of a polarizing microscope, crystallizes on cooling at 143° C. in the form shown schematically in Fig. 1 (right). On further cooling, at 90° C., the crystallites, every one separately, suddenly split up into a series of smaller crystallites, separated by striæ perpendicular to the longest dimension of the original crystal, as shown in Fig. 1 (left). The striated form remains unchanged down to room temperature. On reheating, at 90° C., the striæ disappear, again simultaneously and independently over the whole area of an original crystallite or a large part of it, and, by a number of such flashes,

Fig. 1

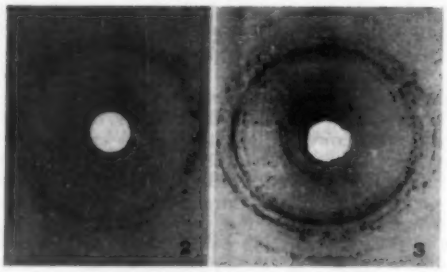

Fig. 2 Fig. 3

the high temperature picture is restored. This can be repeated many times. This transition of the free acid does not occur with the amide, the ammonium or sodium salt.

X-ray photographs were taken both of the high- and low-temperature forms, with iron $K\alpha$ radiation and a camera diameter of 57·3 mm. Liquid suberic acid was sucked into a piece of Mark capillary surrounding an electrically heated axial platinum wire. The whole was rotated through 120° about the camera axis. The temperature-voltage characteristics of the arrangement being known, it was possible to keep the preparation at the temperature desired or to change its temperature quickly. The high-temperature form, crystallized from the melt between 143° and 90° C., in this arrangement forms large and orientated crystals so that only a few spots appeared on the film. In order to obtain measurable rings, it was necessary to melt the acid for 15 sec. and allow it to crystallize anew above 90° C. once a minute for one hour. Figs. 2 and 3 were obtained from the high- and low-temperature form respectively.

Suberic acid is reported[2] to crystallize in the monoclinic system with $a = 10{\cdot}12$ A., $b = 5{\cdot}06$ A., $c = 12{\cdot}58$ A., $\beta = 135°$, two molecules lying parallel to c in a base-centred cell. The diagrams, after subtraction of faint platinum lines, were indexed on this basis, and indices, spacings and estimated intensities are given in the accompanying table for the calculated diagram, for the cold- and the hot-form.

X-Ray Spacings (d) and Intensities (I)

hkl	*d* (calc.)	*d* (cold)	*I* (cold)	*d* (hot)	*I* (hot)
001	8·88	8·55	5	—	—
002 } 011 }	4·44	4·33	3	—	—
110	4·13	4·06	5	4·30	5
200	3·58	3·73	2	3·80	5
012	3·33	3·50	5	—	—
003	2·96	3·04	2	—	—
210	2·92	2·93	4	3·02	3
120 } 300 }	2·40	2·25	2	2·34	1
202	2·14	2·16	2	—	—
221	1·85	1·84	2	—	—

The cold form corresponds to the calculation without systematic deviations. As for the hot form, it is characteristic that only the interferences $hk0$ appear. This can be seen directly in Fig. 2 where, at the position of the inner circle (001) of Fig. 3, only an 'amorphous ring' appears. This ring appears equally with liquid suberic acid and can be ascribed to the liquid state being present during a quarter of the exposure. Hence, the high-temperature modification shows lattice order only in the directions perpendicular to the c-axis, whereas in the c-direction it is 'liquid'.

For the cold form, the smaller angle at the centring chain in the plane perpendicular to c is calculated to be 71°. On transition to the hot form, within the accuracy of the few lines available, calculation indicates a dilatation of 4·5 per cent in the a-direction and a contraction of 3 per cent in the b-direction. This makes the above-mentioned angle decrease to 67°. The same tendency of the angle to approach 60° (hexagonal arrangement) has been observed by A. Müller[3] on heating long-chain paraffins, and is explained by increasing rotation of the carbon chains about the c-axis. If we assume now that at the transition point this rotation begins to cover the full circle, it will eliminate in the hot form a considerable part of the dipole forces between the carboxyl groups of neighbouring parallel chains which, in the cold form, hold these groups in one plane. Thus, a parallel shift of the chains into disordered positions may be made possible.

As for the question why it is exactly that suberic acid shows this interesting type of transition, it is perhaps of interest that the high-temperature modification forms mixed crystals with adipic acid but not with sebacic acid, and that (001) is very weak in the former and strong in the latter. Perhaps the transition point, sharp or not, is situated below room temperature for adipic and above the melting point for sebacic acid, and observable only with suberic acid (only these two acids are comparable, as those with odd numbers of carbon atoms have double elementary cells, see ref. 2).

A flashlike transition has been described also by C. Weygand[4] for "Tridekansäure"; however, we were unable to verify it, either with tridecylic (tridecanoic) or with myristic (tetradecanoic) acid.

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Molecular Interaction and its Relation to the Formation of Sodium Dodecylsulphate–Cetyltrimethylammonium Bromide Complex

It is well known that anionic and cationic detergents are not compatible in aqueous phase when they are present in equimolecular amounts. Compatibility is only observed for certain ratios which depend upon the molecular structure of both components. Precipitation of anionic by cationic detergents present in equimolar amounts constitutes the basis of one of the methods used for their estimation. The work carried out by Salton and Alexander[1] has shown this method to be applicable for determining small amounts of such pure detergents.

When the reagents are not well purified, the above method of titration is no longer valid, due to traces of polar compounds such as long-chain alcohols, which are known to interact with the detergent to form a molecular association. Relatively high amounts of hexyl or heptyl alcohol are needed to prevent the precipitation, whereas the presence of octyl or nonyl-alcohol in equimolecular ratio will inhibit the formation of sodium dodecylsulphate – cetyltrimethylammonium bromide complex. For example, an $M/300$ solution of these substances with octyl alcohol will be completely clear when these reagents are in the molecular ratio 1 : 1 : 1; in the absence of the alcohol a marked flocculation of the sodium dodecylsulphate – cetyltrimethylammonium bromide complex is observed. It is clear that the alcohol – sodium dodecylsulphate complex is competing with the sodium dodecylsulphate – cetyltrimethylammonium bromide association, and that as a result of the presence of the long-chain alcohols (C_8, C_8) the anionic detergent has lost certain of its properties. Schulman[2] has already shown that cholesterol will inhibit precipitation of sodium cetylsulphate by addition of silver nitrate. The results now obtained show that with octyl alcohol a strong molecular interaction occurs and demonstrate the existence of a 1 : 1 complex of sodium dodecylsulphate–octyl alcohol, a conclusion already reached by Matalon[3].

The inhibition of precipitation of anionic by cationic detergents appears then to be due to competition between two types of molecular interaction.

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Exchange of Carbon-13 Dioxide between Solid Carbonates and Gaseous Carbon Dioxide

In connexion with a study of the reaction mechanism of the thermal decomposition of dolomite, we are investigating exchange between carbon-13 dioxide ($^{13}CO_2$) and solid carbonates at high temperatures. To our knowledge exchange reactions using isotopic tracers between gaseous and solid reactants have, so far, only been carried out[1,2] on oxides and oxygen-18.

Depending on temperature and partial pressure of carbon dioxide, dolomite can be decomposed either partially to $MgO + CaCO_3$ or completely to $MgO + CaO$. (Experiments on the isobaric thermal decomposition of dolomite at various pressures of carbon dioxide have been carried out simultaneously and will be published elsewhere.) In order to obtain further information on the reaction mechanism involved, a detailed investigation, particularly on the first stage of decomposition, was thought appropriate. In this case two questions immediately arise: (*a*) Is calcium carbonate primarily formed from the original dolomite lattice ?—$CaMg(CO_3)_2 \rightarrow MgO + CaCO_3 + CO_2$. (*b*) Is dolomite first decomposed to magnesium and calcium oxides, when, under sufficient partial pressure of carbon dioxide, the latter then recombines to form calcium carbonate ?—(i) $CaMg(CO_3)_2 \rightarrow MgO + CO_2 + CaO + CO_2$. (ii) $CaO + CO_2 \rightarrow CaCO_3$.

It was hoped to distinguish between these two mechanisms by studying the thermal decomposition of dolomite in presence of labelled carbon dioxide. $^{13}CO_2$ generated from barium carbonate labelled with 62 per cent carbon-13 was used for experiments, and isotopic abundance ratios were measured on a Consolidated-Nier mass-spectrometer, model 21-201, at an accelerating voltage of 1,160 volts and a magnetic field-strength of 2,200 gauss. A resolving power of 0·043 per cent was obtained and a peak height of 15 volts was used for the 44 peak.

Practically chemically pure well-crystallized dolomite (Thornwood, New York) was used. Finely ground material was spread in a thin layer on the walls of a quartz tube. Generation of carbon-13 dioxide; degassing of solid carbonates; mixing of normal and labelled carbon dioxide and drawing off of samples were carried out under proper conditions on a high-vacuum system. Care was taken to obviate 'memory' and contamination effects at all stages during experiments.

In an initial series (I) (control experiments) dolomite was first decomposed to magnesium oxide plus calcium carbonate at a temperature of 700° C. and a pressure of carbon dioxide of about 400 mm. These conditions were chosen from our experience with isobaric thermal decomposition experiments. As a sequel to this, the solid reaction product was heated for one hour to the same temperature and under the same pressure of carbon dioxide, which, however, now contained approximately 20 per cent carbon-13 dioxide.

In a second series (II) of experiments, thermal decomposition of dolomite was carried out in the presence of carbon-13 dioxide under identical conditions. Initially a degree of exchange was obtained by the difference of carbon-13 content in samples of carbon dioxide gas taken before and after exchange. Greater accuracy, however, was obtained by direct measurement of carbon-13 content of the carbon dioxide evolved when magnesium oxide plus calcium carbonate were completely decomposed after exchange at 700° C., evolved carbon dioxide being condensed with liquid oxygen.

For comparison purposes a sample of calcite (Cherokee County, Kansas) was treated under corresponding experimental conditions with carbon-13 dioxide.

Some of the results obtained are tabulated in Table 1.

Table 1

Experiment	Weight of carbonate (mgm.)	Total pressure of carbon dioxide at 700° C. (mm.)	Atomic per cent carbon-13			
			In reaction gas after exchange	In carbon dioxide evolved on complete decomposition	Calculated for complete exchange	Observed as percentage of complete exchange
Dolomite	100·0	400	1·24*	1·24*	—	—
Dolomite Series I	101·2 100·0	408 422	21·82 19·71	4·48 4·49	14·5 14·3	31·0 31·4
Dolomite Series II	99·4 98·0	395 403	21·24 21·20	5·67 5·72	14·9 14·7	38·1 39·0
Calcite	100·3	397	19·42†	2·80	10·3	27·2

* This shows that isotopic abundance of carbon-13 in normal and bound carbon dioxide is the same.

† Percentage of carbon-13 before exchange was 21·56. From carbon-13 content after decomposition (2·80 per cent), carbon-13 content in the reaction gas after exchange can be calculated. Calculated value 19·6 per cent, observed value 19·4 per cent.

From the above results it is apparent that a considerable exchange occurs between solid carbonates and gaseous carbon dioxide. The exchange in series II, where the dolomite was decomposed in the presence of carbon-13 dioxide, is definitely higher than in series I, where exchange occurred after decomposition to magnesium oxide plus calcium carbonate. With natural calcite there is a distinct exchange which is, however, lower. This is presumably due to the different subdivision of calcium carbonate and consequent difference in surface area available for exchange reaction.

That exchange is a surface effect is an obvious conclusion, in so far as exchange would take place rather rapidly in the surface layer of the solid and then would proceed more slowly into the interior of the particles[2]. To confirm this, the reaction product was completely decomposed after exchange as described. This time, however, the condensate was collected as two or three successive fractions at the time intervals indicated below. These fractions showed a decreasing content of carbon-13, indicating that the most enriched samples were obtained in the first gas evolved (see Table 2).

Table 2

Experiment	Weight of dolomite (mgm.)	Total pressure of carbon dioxide at 700° C. (mm.)	Atomic per cent carbon-13			
			In reaction gas after exchange	In carbon dioxide evolved on complete decomposition of the reaction product MgO + $CaCO_3$. Fractions condensed from		
				0–5 min.	5–15 min.	15–35 min.
Dolomite Series I	100·3 100·1	404 400	20·55 19·84	5·57 5·14	2·80 2·80	2·20 2·25
				0–15 min.		
Dolomite Series II	99·6	385	21·74	5·66		4·01

The higher exchange in series II, which is well reproducible, can be readily explained by reaction mechanism *b*, assuming that calcium carbonate is regenerated by a reaction of primarily formed calcium oxide with carbon dioxide from the gas phase. So far, however, it is not possible to exclude the alternative mechanism, namely, the primary formation of calcium carbonate from the original dolomite lattice. In this case, higher exchange may be due to a higher reactivity of calcium carbonate during rearrangement of the lattice (Hedvall effect).

At the moment it is preferable to leave the question open and to discuss it further in conjunction with present X-ray investigations on thermally decomposed single crystals of dolomite.

Experiments on rate of exchange at different temperatures and pressures are contemplated, and surface area measurements will be carried out in conjunction with these.

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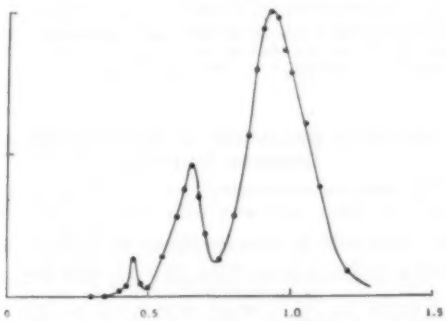
Radio Reflexions from a Column of Ionized Gas

A THEORETICAL discussion by Herlofson[1] shows that a narrow ionized column—such as a meteor trail—will be a particularly good reflector for radio waves of frequency ν if the electric vector in the waves is perpendicular to the axis of the column, and the electron density is approximately equal to $\frac{2\pi m}{e^2} \cdot \nu^2$. (Mr. Herlofson informs me that his note in *The Observatory* is not correct ; in particular, resonance will occur for values of ε near -1 instead of 0. A revised theory will be published elsewhere.) In this case, even a column which is very narrow compared with a wave-length will reflect as efficiently as a metal strip with a width comparable to a wave-length. The strong reflexion is a resonance effect, and will be damped if the electron collision frequency is not small enough.

This effect has been studied by measuring the reflexion of 30-cm. radio waves from a mercury discharge in a tube with a diameter of 3·2 cm. and a length of 80 cm. This diameter was chosen because it is a small fraction of a wave-length and hence would show the resonance effect clearly. In addition, the electron density as function of discharge current is known for a tube of this diameter from probe measurements by Langmuir and Mott-Smith[2].



Amplitude of reflected wave as a function of discharge current (amp.)

The radiation was supplied by a 10-W. transmitter with a Yagi aerial 1·5 metres away from the tube, and the reflected signal was measured at the same distance from the tube by a similar aerial connected to a crystal detector. The two aerials were separated by about 50 cm.

Disturbing reflexions from the glass tube and the laboratory walls were often comparable to the reflexion from the discharge ; but they could be eliminated by repeated measurements with the discharge tube in different positions over a range of one-fourth of a wave-length.

The vapour pressure was kept independent of the discharge current by a powerful air blast which cooled the tube walls to about 25° C. Special precautions were taken to eliminate instabilities in the discharge current, which would have a marked influence on the measurements.

The accompanying graph is typical for the results obtained. From the data of Langmuir and Mott-Smith, resonance was expected to occur for a discharge current of about 0·8 amp. The main peak is observed at 0·93 amp. The maximum power reflected from the discharge amounted to about 80 per cent of the power reflected from a metal strip half a wave-length wide.

The existence of multiple resonance peaks had not been anticipated, and is not yet fully explained. If the amplitude and phase of the reflected wave are plotted in the complex plane, three resonance loops appear. It is noteworthy that the ratio between the discharge currents for successive maxima (and hence between the electron densities) is equal to $\sqrt{2}$ within the accuracy of measurement.

If the aerials were turned 90° about their axes, so that the plane of polarization became parallel to the discharge tube, the amplitude of the reflected wave became unobservable for all values of the discharge current. Similarly, any radiation in a direction 90° from the incident beam was masked by radiation reflected from the glass tube.

In a preliminary investigation of the effect of electron collisions, the cooling air blast was removed. The rise of temperature increased the mercury vapour pressure by twenty times, and the amplitude of the resonance maximum fell to a small fraction of the amplitude at 25° C.

Denno, Prime and Craggs[3] have recently reported a set of similar measurements with 3-cm. radio waves ; but since their tube diameters are equal to, or larger than, the wave-length, a comparison of their results with theory or with the present experiments is not easy.

DAG ROMELL

Department of Electronics,
Royal Institute of Technology,
Stockholm.
Oct. 11.

[1] *Observatory*, **68**, 230 (1948).
[2] *Gen. Elec. Rev.*, **27**, 762 (1924).
[3] *Proc. Phys. Soc.*, B, **63**, 726 (1950).

Single-Crystal Neutron Diffraction Analysis

IN the past five years, neutron diffraction analysis has been carried out with wide neutron beams and specimens of several cubic centimetres in volume, in order to obtain a manageable diffracted intensity. Such an expedient has many disadvantages. In the powder method it leads to bad resolution, and incoherent scattering in the sample produces a background which is sometimes larger than the significant counting-rate. This is particularly serious for the study of hydrogenous substances, which give large disordered scattering, and it has been widely concluded that deuterium compounds must be used in their place. With single-crystal methods the limitation arises from the severe extinction of the neutron beam. A single crystal suitable for structure analysis must in general have dimensions of about 1 mm.[1].

A technique is now proposed which permits the use of a small single crystal in conjunction with a pile of only moderate neutron flux. It has the following advantages over prevailing methods : the counting-rates are greater ; the ratio of Bragg peak to background count is improved to the degree that many hydrogen-containing substances may be studied ; and the use of a small single crystal means that structures of greater complexity may be attempted.

To gain the necessary intensity, the incident radiation is not monochromatized, but comes straight from the pile (Fig. 1). In these circumstances the collima-

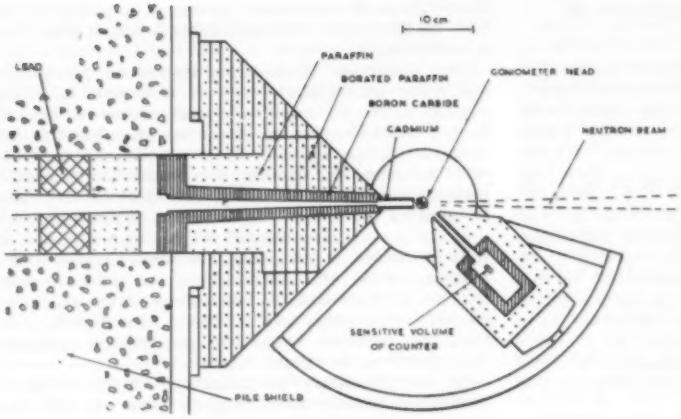


Fig. 1. Neutron spectrometer

tion may be relaxed : a geometrical gain of order 10 follows, since the solid angle from which diffracted neutrons are received at the counter is equal to the whole angular aperture of the collimator, instead of the small angular divergence of the beam reflected from a monochromating crystal. In the apparatus shown, a pencil of diffracted radiation from a crystal of dimensions up to 2 mm. may be intercepted, between Bragg angles of 13° and 59°, by a miniature counter[2] of efficiency 20 per cent.

The 'integrated reflexion' to be measured in a structure analysis by this method is the peak counting-rate of the crystal rocking curve. This is recorded for each reflexion of interest with an independent setting of both crystal and counter. Over the range 3·2–0·85 A. of d spacings, it can be so arranged that the mean wave-length taking part is always that which, independently of d, gives the maximum counting-rate. The shape of the pile spectrum then discriminates against the higher- and lower-order reflexions from the plane examined.

The confusion of all the orders of a given plane is, of course, the fundamental weakness of the method. If the structure factors of all orders are the same, second-order impurity in the first-order beam is only about 3 per cent ; but subharmonic impurities in the higher-order reflexions give rise to large corrections.

Rocking curves from small crystals of sodium chloride and naphthalene are reproduced in Fig. 2, and show intensities about ten times what is commonly obtained with a few cubic centimetres of powder. The peak-to-background ratio for sodium chloride may be compared with the published value of 3½ obtained by the powder method[3]. The improvement, like the increase in intensity, is sufficiently in excess of expectation to suggest that the powder technique is capable of still further development. Indeed, the intensity is enough to show that with projected high-flux piles, neutron diffraction analysis may be pursued with small crystals and monochromatic radiation in a manner altogether similar to that of modern X-ray crystallography.

The curve for naphthalene indicates that information about hydrogenous organic structures is already within reach of the methods of neutron diffraction.

R. D. Lowde

Atomic Energy Research Establishment,
Harwell.
Oct. 2.

[1] Bacon, G. E., and Lowde, R. D., *Acta Cryst.*, **1**, 303 (1948).
[2] Lowde, R. D., *Rev. Sci. Instr.*, **21**, 835 (1950).
[3] Wollan, E. O., and Shull, C. G., *Phys. Rev.*, **73**, 837 (1948).

Electrical Behaviour of Non-Aqueous Disperse Systems

The electrical conductivity of dispersions of conductive powders increases with time of rest after shear according to the expression : $\frac{dC/dt}{C} = Kt^n$, where n is an exponent between unity and 1·5, and K is equal to $\frac{dC/dt}{C}$ when time is unity. The instantaneous conductivity, however, at any given state of rest after shear increases with increase in the A.C. or D.C. potential applied, attaining an asymptotic value at an E.M.F. depending on the composition of the material. Measurement of specific inductive capacity of flocculated dispersions on an A.C. bridge presents great difficulties owing to the time involved in securing a balance and the constant growth of conductivity due to thixotropic effect. Nevertheless, indications are shown of specific inductive capacities of the order of thousands when measured at 50 cycles, down to tens at 300,000 cycles.

The specific inductive capacity of deflocculated systems of low conductivity varies very little with shear history when measured at 1 volt on an A.C. bridge. At D.C. voltages up to 120 volts, the specific inductive capacity as measured by a discharge of

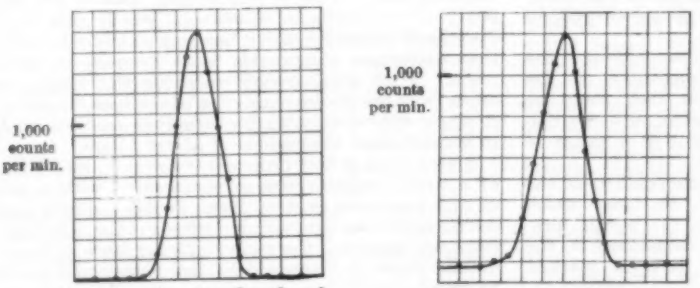


Fig. 2. Rocking curves from : (*a*) 1·3 mm.³ of sodium chloride, (200) plane, mean wave-length 1·48 A.; and (*b*) 0·9 mm.³ of naphthalene, (001) plane, mean wave-length 3·30 A.

the system, arranged as a condenser, through a ballistic galvanometer may be up to fourfold of those recorded at 1 volt A.C. Under these experimental conditions, flocculated systems comprising conducting particles exhibit values of specific inductive capacities reaching one or two thousand in spite of their high conductivities, and their slow rate of charge leakage is completely out of agreement with their known conductivities. Their specific inductive capacities also increase with the time under charge, often only attaining a maximum value in sixty seconds. Immediate remeasurement at a lower E.M.F. reproduces the specific inductive capacity originally shown at the lower voltage, so that the effects noted cannot be due to progressive flocculation or the more intense flocculating action induced by the electric field.

The high specific inductive capacities of flocculated dispersions must be connected in some manner with their superimposed conductivities, since dispersions of non-conductive powders show vanishingly small conductivities and low specific inductive capacities even when flocculated.

The high specific inductive capacities of flocculated systems cannot be ascribed entirely to the reduction of volume of the dielectric medium arising from the presence of the conducting particles, as deflocculated systems of similar volume concentrations show values little greater than that of the medium. Rather is it connected with the friction exhibited by the thin quasi-solid interstitial films of the medium, which give rigidity to the dispersion at concentrations of disperse phase well below those corresponding to critical packing.

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R. W. RAINBIRD

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Oct. 12.

Effect of Ultrasonic Vibrations on Filariasis of the Cotton Rat (*Sigmodon hispidus*)

SMALL animals are very susceptible to minute doses of ultrasonic vibration. We have tried to influence the parasites of experimental infections with *Bilharzia Mansoni* in mice and *Litomosoides carinii* in cotton rats.

With *Bilharzia*, we observed no result at all. With *Litomosoides*, we noticed in two animals a very definite action on the microfilariæ very akin to the action we observed with S. Bettini[1] on *Filaria immitis* of the dog after injection of dibromosalicyl. Our apparatus worked on a frequency of 940 kc./s.

(1) Two cotton rats were held on their backs, and their chests wetted with water. The quartz vibrator was rubbed on the chest, on the first at 1·5 watts/cm.², on the second at 2 watts/cm.², for two minutes. In the first cotton rat, we noticed a decrease from 100 to 9 microfilariæ in ten fields during the first week; then they rose again to 40.

In the second cotton rat, microfilariæ were reduced from 30 to 4 during the first week. The animal suffered from diarrhœa and conjunctivitis, and died on the eighth day. The adult filariæ in it were alive; when the head was cut off, we noticed the effect mentioned earlier[1], namely, larvæ at the morula stage and some others more advanced, but granular and irregular.

(2) In a second experiment with three cotton rats, every animal received one daily treatment during three successive days with 1·5 watts/cm.² during 1, 2 and 5 min., and a daily blood examination was made.

In the first rat, there was no action at all. In the second, the microfilariæ fell from 25 to 3 and remained so for several days. The third (fall from 30 to 1) died on the seventh day, with the same symptoms as those observed in the first experiment. Adult filariæ were alive; but the appearance of the uterine content, after decapitation, was the same as in the first experiment.

The fact that the two cotton rats which received the highest dose in the two experiments died with similar symptoms and showed similar action on the microfilariæ suggests that this was due to the ultrasonic vibrations, probably acting on the parasites. We were unfortunately unable to try other frequencies which might be more effective against the parasites and less harmful to the host.

Acknowledgment is due to Dr. A. Argamakoff, who kindly let us use an apparatus of his own construction.

E. LAGRANGE

Division Pharmaceutique,
Union Chimique Belge,
Brussels.
Oct. 6.

[1] Bettini, S., and Lagrange, E., *Riv. di Parassitologia*, 8 (1947).

Angstrom Units, A. or Å.?

IN 1907 the International Solar Union (later to be embodied in the International Astronomical Union) adopted I.A. for 'International angstrom'. In a report on series in line spectra prepared by A. Fowler for the Physical Society in 1922 the author says: "The unit of wavelength is the Ångström unit or 'angstrom', as it is now beginning to be called".

Since that time the use of the letter 'A.' has been in general use among spectrographers, until just recently certain authors have begun to write 'Å.' again. This would appear to be a retrograde step. It is certainly not in accord with the practice of most established workers in the subject.

In the well-known report on symbols issued by a joint committee of the Chemical, Faraday and Physical Societies in June 1937, the small capital roman 'A.', with no accent, is the accepted symbol. It also occurs thus in the Spectrophotometric Terms and Symbols laid down by a Committee for the Society of Public Analysts in 1942. Picking up a few books at random, I find that in report No. 9 on Progress in Physics, 1942–43, C. H. Bamford uses 'A.'. In the same publication R. W. B. Pearse, in a paper on "Spectra in the Night Sky", uses 'A.'; the same author in a recent Royal Society paper on the identification of molecular spectra again writes 'A.'. As for American authors, Brode ("Chemical Spectroscopy"), Sawyer ("Experimental Spectroscopy") and most authoritative of all, George R. Harrison in his "Wavelength Tables", all use 'A.'. Examples might be multiplied indefinitely, while among the hundreds of English industrial spectrochemical analysts, the practice of writing 'A.' is, I believe, universal.

F. TWYMAN

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 12

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Inventor, Engineer and Manager" (to be opened by Mr. P. P. Eckersley).

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (at the University, Manchester), at 5.30 p.m.—Prof. S. C. Harland, F.R.S.: "The Evolutionary History of Cotton" (Percival Lecture).

Tuesday, February 13

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. David Cox: "The Organization of Repetitive Tasks".

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.8), at 5 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. A. Hine: "The Inductor Compass".

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. C. W. Bonniksen: "The Manufacture of Alginates".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Mr. H. A. Sieveking: "Some Aspects of the Development of Hydro-electric Power".* (Further Lectures on February 20, 27 and March 6.)

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, S.W.1), at 7 p.m.—Mr. D. J. Lambert: "Derivation and Estimation of Aerodynamic Loads for Stressing Purposes".

Wednesday, February 14

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. D. McKie: "1851–1951, a Century of British Science".

UNIVERSITY OF LONDON (at Westfield College, Kidderpore Avenue, London, N.W.3), at 5.15 p.m.—Prof. E. N. da C. Andrade, F.R.S.: "Science in the 17th Century".*

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. T. C. G. Thorpe: "Petroleum Waxes".

MANCHESTER STATISTICAL SOCIETY (at the Reform Club, King Street, Manchester), at 5.30 p.m.—Mr. H. Campion: "Recent Developments in Economic Statistics".

INSTITUTION OF ELECTRICAL ENGINEERS (at Central Hall, Westminster, London, S.W.1), at 6.30 p.m.—Mr. L. J. Davies: "Lamps and Lighting—a Record of Industrial Research". (Farsday Lecture.)

INSTITUTION OF WORKS MANAGERS, MERSEYSIDE BRANCH (joint meeting with the INSTITUTE OF COST AND WORKS ACCOUNTANTS AND THE INSTITUTION OF PRODUCTION ENGINEERS, at Radiant House, Liverpool), at 6.30 p.m.—Mr. W. C. Puckey: "The Measurement of Productive Efficiency".

MANCHESTER METALLURGICAL SOCIETY (joint meeting with the IRON AND STEEL INSTITUTE, at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Mr. R. Toye: "Instrumentation of Steelmaking Furnaces—some of the Problems".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at the Royal Sanitary Institute, 90 Buckingham Palace Road, London, S.W.1), at 6.30 p.m.—Discussion on "The Training of Food Technologists" (to be opened by Dr. J. B. M. Coppock).

SOCIETY OF GLASS TECHNOLOGY (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6.30 p.m.—Dr. R. R. Pearce: "The Use of Glass in Television".

SOCIETY OF INSTRUMENT TECHNOLOGY, CONTROL SECTION (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6.30 p.m.—Mr. G. G. Sutton: "The Design of an Automatic Spectrometer".

INSTITUTE OF FUEL, NORTH-WESTERN SECTION (joint meeting with the STANLOW BRANCH of the INSTITUTE OF PETROLEUM, at the Grosvenor Hotel, Chester), at 7 p.m.—Mr. C. D. Brewer and Mr. B. H. Thorp: "The Influence of Fuel Characteristics on the Behaviour of Compression Ignition Engines".

TEXTILE INSTITUTE, MIDLANDS SECTION (joint meeting with the MIDLAND SECTION of the SOCIETY OF DYERS AND COLOURISTS, in Room 104, College of Technology, Leicester), at 7 p.m.—Mr. E. J. Davies: "The Reactions of Fabrics and Finishes to Dry-Cleaning".

BRITISH INSTITUTION OF RADIO ENGINEERS, SOUTH MIDLANDS SECTION (at the East Midlands Electricity Board, Coventry), at 7.15 p.m.—Mr. H. J. Barton-Chapple: "A Survey of Television Development and its Problems".

Thursday, February 15

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. W. J. Corlett: "Population Trends".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.40 p.m.—Scientific Papers.

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. H. E. Jeffrey: "Notes on Fire Prevention and Fire-Fighting, with particular reference to the Kolar Gold Field"; Mr. Victor Hodgson: "Filling Stopes with Glacial Drift at Buchans, Newfoundland".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. D. V. Lindley: "Mathematical Foundations of Statistics".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. F. S. Dainton: "Atoms and Radicals in Aqueous Solutions". (Tilden Lecture.)

ROYAL AERONAUTICAL SOCIETY (at the Sibree Hall, Coventry), at 7.30 p.m.—Mr. Handel Davies: "Some Aspects of Flight Research".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. J. Newsome: "Recent Investigation into the Treatment of Schistosomiasis by Miricil D in Egypt".

UNIVERSITY OF LONDON (in the Swanley Hall, Wye College, Wye, Kent), at 8.15 p.m.—Prof. C. H. Waddington, F.R.S.: "Science and Ethics".*

Friday, February 16

SOCIETY FOR ENDOCRINOLOGY (at the Zoological Society, Regent's Park, London, N.W.8), at 11 a.m.—Symposium on "Endocrinological Aspects of Fertility".

EUGENICS SOCIETY (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Dr. G. C. L. Bertram: "Eugenics and Human Ecology" (Galton Lecture).*

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Air-Commodore F. R. Banks: "The Aviation Engine" (James Clayton Lecture).

SOCIETY OF DYERS AND COLOURISTS, MANCHESTER SECTION (at the Gas Showrooms, Town Hall Extension, Manchester), at 6.30 p.m.—Dr. H. W. Ellis: "The Physical Measurement of Dyeing, with special reference to the Ellis Photometer": Discussion on the Physical Society (Colour Group) Colour Terminology Report (introduced by Mr. G. S. J. White).

ROYAL INSTITUTE OF CHEMISTRY (at the Technical College, Brighton), at 7 p.m.—Dr. W. H. J. Vernon: "Corrosion Processes and their Prevention".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Scientific Papers.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. C. F. Powell, F.R.S.: "The Cosmic Radiation".

Saturday, February 17

BRITISH INTERPLANETARY SOCIETY, NORTH-WESTERN DISTRICT CENTRE (at the Adult Education Institute, 49 Lower Mosley Street, Manchester), at 7 p.m.—Mr. J. Humphries: "The Design of Rocket Motors".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIFIC TECHNOLOGIST (with a good general training in chemistry, preferably up to degree standard) in the Coal Survey Laboratory in Glasgow—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/291 (February 17).

SENIOR HOSPITAL PHYSICIST (with honours degree in physics and experience in hospital physics) at the Radiotherapy Centre—The Secretary, United Birmingham Hospitals, Queen Elizabeth Hospital, Birmingham 15 (February 17).

FUEL TECHNOLOGIST (with first- or second-class degree in applied chemistry, or equivalent), and a FUEL ANALYST (pass degree in chemistry or equivalent desirable)—The Personnel Manager, Colonial Development Corporation, 19 Curzon Street, London, W.1, quoting Serial No. 54 (February 19).

PRINCIPAL OF THE WOLVERHAMPTON and STAFFORDSHIRE TECHNICAL COLLEGE—The Director of Education, Education Office, Wolverhampton, endorsed 'Principal of Technical College' (February 22).

ASSISTANT LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING (electrotechnics)—The Registrar, The University, Liverpool (February 24).

SCIENTIFIC OFFICER (with an honours degree in chemistry with postgraduate experience in agricultural chemistry, or an honours degree in agricultural chemistry) IN THE CHEMICAL RESEARCH DIVISION of the Ministry of Agriculture—The Director of Establishments, Ministry of Finance, Stormont, Belfast (February 27).

CHIEF LECTURER IN PHYSIOLOGY at the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 10).

LECTURER or ASSISTANT LECTURER IN CHEMISTRY, an ASSISTANT LECTURER IN BOTANY, an ASSISTANT LECTURER IN MATHEMATICS, and an ASSISTANT LECTURER IN ZOOLOGY, at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 31).

PROFESSORSHIP IN THE DEPARTMENT OF PHYSICS—The Registrar, University of Manitoba, Winnipeg, Canada (March 31).

PERROTT STUDENTSHIP IN PSYCHICAL RESEARCH—The Secretary, Perrott Studentship Electors, Trinity College, Cambridge (April 30).

ANALYST to take charge of the chemical laboratory connected with crop testing—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

LECTURER IN BIOLOGY, to take classes up to final degree standard in zoology and/or botany—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1.

RESEARCH ASSISTANT, with degree in chemistry, physics or engineering—The Assistant Secretary, British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey.

SCHOLARSHIPS IN TEXTILE TECHNOLOGY, TEXTILE ENGINEERING, TEXTILE CHEMISTRY or DYEING—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

SENIOR ASSISTANT IN THE DEPARTMENT OF PHYSICS—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

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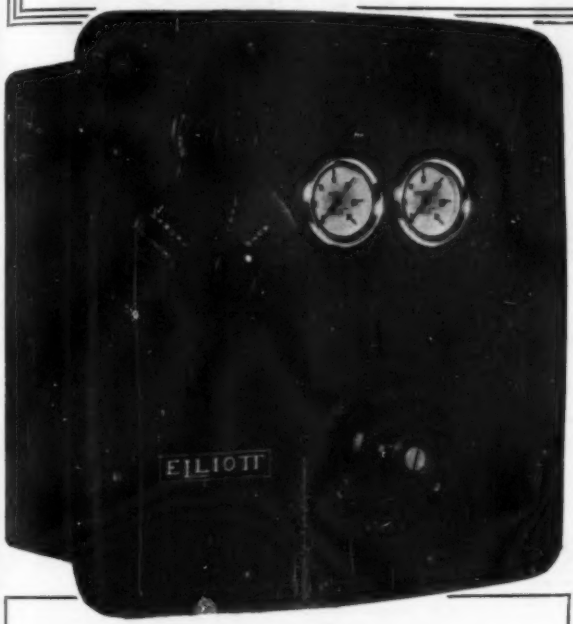

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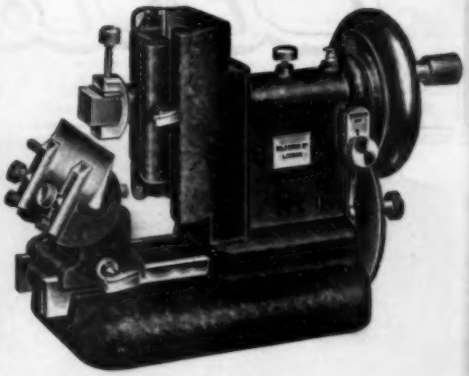

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